JOURNAL SMPTE

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Headquarters Office: 55 West 42nd St., New York 36, N.Y. Telephone: LOngacre 5-0172

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Principles of Special Photographic Effects

By JOSEPH WESTHEIMER

The aim of special photographic effects is to produce a duplicate negative which contains an image as a result of one or more exposures. The various methods for making the exposure or exposures are described in terms of equipment and the diagrammatic evolution of that equipment. This paper attempts to coordinate the many specialized phases of trick photography toward a common ground. There is first contact duplication without a lens; a lens is added allowing selective duplication and consequently matte shots. By removing the films from contact position and placing a lens between them, an optical printer is represented. Lastly, another lens and a translucent screen are added to the system displaying the projection background process.

THE MANUFACTURE of a duplicate negative containing an image as a result of one or more exposures is today the primary purpose for the existence of special photographic effects. A duplicate negative, or dupe negative, as it is commonly called, is a facsimile or reproduction of the original in both density and contrast. It is required to introduce not only the many transitional effects such as fades and dissolves that are seen in present-day films, but also visual effects such as matte shots which alter the content of the original by means of matting and superimposure.

A duplicate negative, therefore, may contain a dissolve having the combined images of two pieces of film, multiple matting and superimposures, as is done on the optical printer, or the combination of foreground action and large-screen photography, as in the projection background process.

Basically, the method of making a duplicate negative is as follows: a master positive print from the original negative is placed in the proper relation to negative raw stock and an exposure is made. The developed raw stock yields a negative which is a duplicate of the original.

In practice, the positive print is made on an intermediate stock known as duplicating positive, commonly called "master positive" or "fine-grain." The negative raw stock exposed in making the duplicate negative is also a special emulsion having low speed, extremely fine grain and a high resolving power, and is intended as a companion to the duplicating positive.

A description of the various methods used to expose duplicating negative raw stock is the purpose of this paper. The method selected depends upon the type of duplication essential to attain the desired result. Although the processes described refer to black-and-white photography, they are adaptable with suitable modification to color.

That the duplicate negative plays an integral part in motion-picture production is demonstrated in Fig. 1. It can be noted that the original camera negative is added to the dubbed track in order to make composite prints.

In general, whenever sections of a picture require either transitional or visual effects, duplication of the original negative is required. Duplicate negatives, which will contain the effects, can be made from a master positive. The duplicate may then be cut and assembled with the original and added to the dubbed track to make a composite print.

In addition to providing protection for the original negative in case of loss by fire or deterioration in storage, it is sometimes advisable to duplicate a negative in order to improve quality. Negatives may be very contrasty, very flat, too thin or otherwise difficult to print within a normal printer range; duplication serves to even out scenes so the release prints will be composed of scenes of uniform quality.

Contact Duplication

A fundamental method of exposing the duplicate negative is that of placing the two films emulsion to emulsion and in contact during exposure. An incandescent lamp provides illumination to print the positive on to the duplicate negative raw stock. Since both the films are threaded through a camera movement having full-fitting registration pins and using the same perforation as the production camera, we are assured of the accurate placement of each frame.

Figure 2 shows a machine built upon these principles. The negative raw stock is placed in a camera magazine

Presented on May 3, 1954, at the Society's Convention at Washington, D.C., by Cmdr. Charles A. Van Dusen, USN, for the author, Joseph Westheimer, Consolidated Film Industries, 959 Seward St., Hollywood 38. Mr. Westheimer has taught Special Photographic Effects for the past four years at the University of Southern California.
(This paper was received on April 28, 1954.)

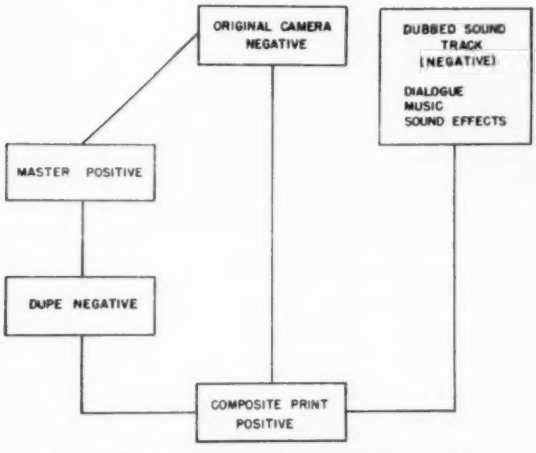

Fig. 1. The importance of the duplicate negative.

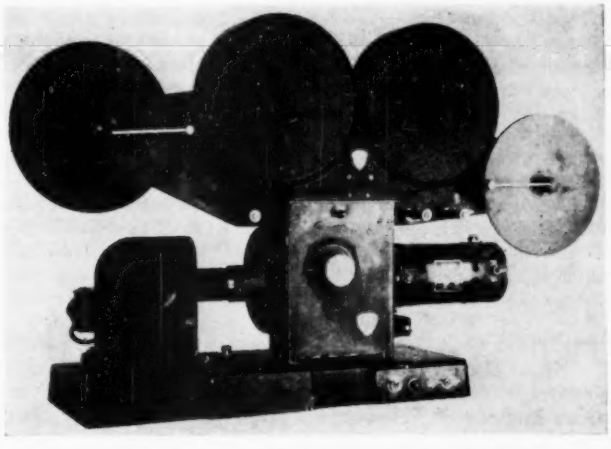

Fig. 2. A contact printer. (Courtesy of Producers Service Co.)

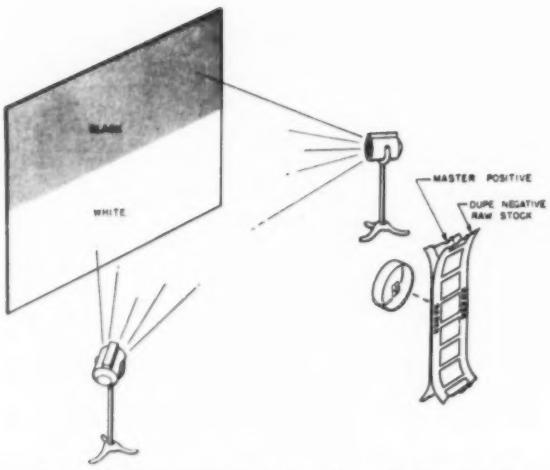

Fig. 3. Contact duplication in matte-shot photography.

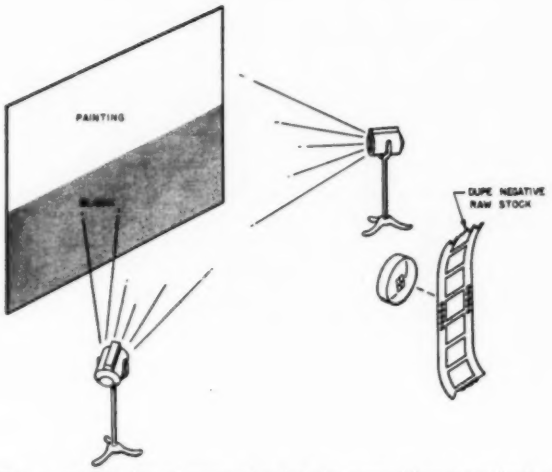

Fig. 4. Completion of matte shot by photographing the painting.

while the master positive is open to light on the two flanges. A camera motor drives the system at various speeds, and exposure can be further controlled by inserting filters in a slot provided in front of the camera movement.

Although we are concerned here with the exposing of duplicate negatives, it may be noted that the contact printer is used for other operations where accurate and positive film registration is essential. It is used for printing master positives used in the projection background process, making traveling mattes for use on the optical printer and, most important with the present extensive use of color, the making of color separation master positives for the duplication of color negatives.

By the addition of a lens to this equipment, as shown in Fig. 3, the system still duplicates by contact, but the illumination comes from a white board or card instead of a lamphouse with associated condensers. The two films travel through the movement emulsion to emulsion and in contact during exposure; the addition of a lens allows the cameraman to "selectively duplicate" portions of a master positive.

The two films and lens constitute a camera whose lens is focused upon an illuminated white card. The introduction of a black area upon the white card precludes the possibility of an exposure reaching the duplicate negative raw stock in those areas. Since the lens is focused upon the black area, the image of the black area on the duplicate will also be sharp. The selective duplication of scene is known as matting and an excellent example of its application is the matte shot.

The Matte Shot

A visual effect employing composite photography which combines live action with a painted scene is known as a glass or matte shot. Early matte shots consisted of a painting on part of a large piece of glass. A production camera photographed the action through the clear portions of the glass and the painting at the same time. For obvious reasons it was called a glass shot and the name persisted after the advent of duplicating emulsions. Artwork in this method had to be completed and the setup tested before the scene could be photographed. Present-day matte shots have the advantage of duplication allowing the painting to be made and added to the production scene long after the original photography.

Matte shots require that utmost care be taken in exposing the original negative when photographing the production scene. Of primary importance is the selection of a camera which is "steady." This implies that consecutive frames are in the same position in relation to the full-fitting pilot pin. In addition, the camera must be securely anchored and may not be panned or tilted during exposure.

Assuming the action to take place in the lower portion of the frame, a master positive is made of the production scene and placed in the camera as in Fig. 3. It is emulsion to emulsion with the duplicating negative raw stock, in contact during exposure and inverted. An illuminated board painted black across the top portion and white along the bottom is placed in front of the camera. As an exposure is made, the white area allows the master positive to print on to the duplicate negative raw stock while the black area allows no light to reach the negative. Duplication has taken place in the section of the frame in which the action occurred and no exposure has been made where the painting is to be photographed.

The master positive is removed and the duplicating negative raw stock is rewound to the start of the scene. Photographing the painting which is substituted for the black-and-white card as in Fig. 4 completes the matte shot.

It may be noted that the dividing line between the black-and-white portions of the board, known as the blend line, establishes a region wherein the painting and master positive are combined. In the discussion above, the line has been indicated to be sharp, although it is not necessary for this to be the case. Certain scenes require the line to be soft or out of focus so that it will not be detected. To further escape detection, the line may zig-zag across the screen. Sharp blends are those which are in sharp focus, but when soft blends are required they may be made by either airbrushing an in-focus blend, or by moving the black area or matte toward the lens until it is out of focus by the desired amount.

Figures 5 and 6 demonstrate the advantages that matte shots offer in enhancing the photographic value of a motion picture, by presenting scenes which would be prohibitive in cost, if not impossible to construct.

Contact duplicating principles are used in many special types of visual effects, the foremost being placing titles over a moving scene. Titling is such a broad field that it can only be mentioned here, since time does not permit a discussion of it.

The Optical Printer

In order to eliminate the restrictions inherent in contact duplication, an arrangement which increases its versatility manyfold and yet consists of a simple arrangement of lens, master positive and duplicate negative raw stock is shown in Fig. 7. An apparatus for optical duplication, known as the optical printer, has been diagrammed by removing the two films from each other and inserting an optical system between them.

In contact duplication the two films progress through the same movement frame for frame and are "in step" with each other throughout the process. In optical duplication the films travel

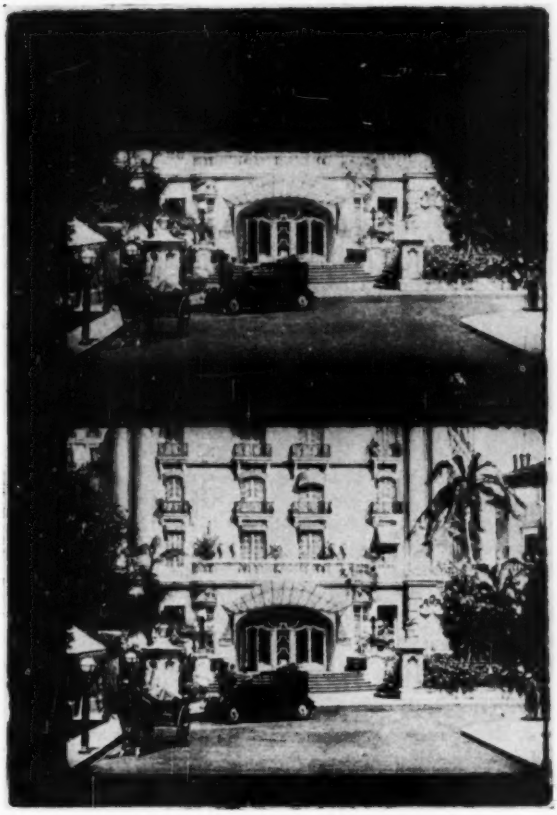

Fig. 5. Example of a matte shot. This is an exterior scene on a studio street. Note the height to which the sets were constructed. (Courtesy of the Hal Roach Studio.)

Fig. 6. Example of a matte shot. This is an interior set. It serves to illustrate savings effected through the use of matte-shot photography. (Courtesy of the Hal Roach Studio.)

through separate movements, a fact which makes it necessary for the optical printer to be equipped with a driveshaft connecting the camera and projector. This driveshaft or mechanical interlock insures that the shutter is closed while the master positive and duplicate negative raw stock are being transported from one frame to the next.

The full-fitting or large pin enters the same perforation in relation to the frame being photographed in both contact and optical duplication. Since the lens inverts the image, as can be noted in Fig. 7, it is necessary for the full-fitting pin to be above the reference frame in the projector and below the frame in the camera and on the opposite side. It is for this reason also that the master positive travels upward in relation to the lens, while the negative duplicating raw stock moves downward as indicated by the arrows.

Fades and Dissolves. Many contact duplicating cameras and all optical printers include a variable shutter which may be adjusted from completely closed, obliterating all light reaching the film, to full open, allowing the maximum amount of light to reach the duplicate negative raw stock. Shutter openings are calibrated in degrees allowing the cameraman to make exposure changes during fades and dissolves at high optical-printer speeds.

Probably the most used transitional effects are fades and dissolves. In making a fade, the exposure is varied at an even rate until normal density is reached in the case of a fade-in, or until all exposure is removed as in a fade-out. Although other methods may be used to vary the exposure, it is customary to adjust the shutter opening.

Dissolves are a fade-in superimposed over a fade-out and special care must be taken to insure that the density of the image on the duplicate negative remains normal during the transition between the two scenes.

There are two important differences evident between optical and contact duplication. Since the master positive and duplicate negative raw stock progress through different movements, it is possible (1) to have a continuously variable relationship between the size of the image and the object of the lens (e.g., the blowup, reduction and zoom); and/or (2) to duplicate and delete certain predetermined frames of the master positive (e.g., the skip-frame) or, conversely, to duplicate by photographing each frame more than once (e.g., the double-frame).

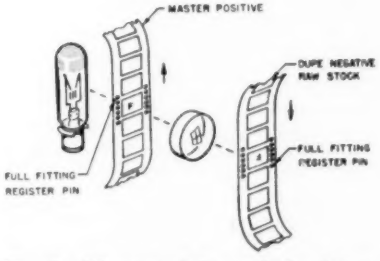

Fig. 7. Diagram of the optical printer.

The Blowup and Reduction. In current motion-picture practices, the continuously variable relationship between the size of the master positive and its image constitutes a major function of the optical printer. Printers have been constructed in which the master positive, the duplicating negative raw stock and the lens have three degrees of freedom separately and independently from each other. Modern design includes features to facilitate the efficient handling of any and all operations which have been done on all-purpose optical printers, thus satisfying the demands of the motion-picture studio and film laboratory.

A blowup is an enlargement of a portion of a frame. It is the optical duplication of a section of the master positive with the image filling the frame on the duplicate negative stock. Blowups are required for the elimination of microphones, lamps or their shadows which may have been photographed in error, and for individual close-ups to obtain a needed cut for proper editing of the picture.

In making a blowup, the lens is extended and moved closer to the master positive; however, in making a reduction, the lens is moved closer to the duplicating negative raw stock. In this process, the image of the master positive is reduced into a portion of the frame on the duplicate negative raw stock. It is commonly seen in motion pictures when a scene is reduced into a motion-picture screen or television set. It may be used in montages as well as many other operations less obvious to the viewer.

By proper adjustment of the projector and lens, it is possible to move up or zoom to the blowup position. Zooms may travel either straight toward the center of the master positive or "off center," in which case the zoom may hold an edge of the frame for the duration of the move.

In the 16mm field, enlargement to 35mm film size from 16mm, and reductions to 16mm from 35mm, are fundamental examples of the extent to which this ability of optical printers is used.

The Skip-Frame and Double-Frame. The second basic difference between optical and contact duplication refers to differential duplication. It is either the deletion of frames according to a predetermined sequence or the duplication of a frame more than once, also following a predetermined sequence.

When deletions are required, every-other-frame or a skip-frame duplicate may be used. More than one frame may be skipped and every second, third, fourth, fifth or more frames may be eliminated.

In a similar manner, a given frame may be duplicated any number of times. An extreme case is a hold-frame duplicate in which a single frame is held throughout the duplicating operation. Sequences can be set up to hold a frame of the master positive in photographing position while two frames of the duplicate negative raw stock are exposed. The next frame of the master positive is moved into position and it also is photographed twice. This sequence is known as a double-frame duplicate. It is possible to photograph a given frame any number of times before progressing to the next one.

When skipping frames, we speed up the action; when duplicating each frame more than once, the action is slowed down. Optical printers have been constructed in which any desired sequence may be obtained simply by presetting the information into the machine; the duplication can be performed for hundreds of feet while the printer is otherwise completely unattended.

Special Duplication Procedures. Another operation performed by the optical printer is that of making a flop-over or turn-over duplicate. This implies that the master positive is turned over, changing the direction of the action from left to right. When the master positive is turned over in the projector, we are no longer duplicating emulsion to emulsion, but instead are photographing through the base support. Since camera-aperture standards have placed the frame off center, either the projector, the lens or the camera must be moved horizontally an appropriate amount to compensate for the soundtrack.

A reverse duplicate negative is a duplicate negative in which the master positive has been duplicated from the end of the scene to the beginning, or foot to head. The projector runs in reverse and the master positive in a downward direction, the same as the camera. This effect is commonly used for gag shots in which a diver may leave a springboard, hit the water and then return to the board. The reverse duplicate is not to be confused with the flop-over duplicate, although both may reverse the direction of the action when an object is moving cross screen.

In the same way that matting is accomplished in matte shots, it may be performed on the optical printer. Where sharp mattes are necessary they may be placed at either of the two planes of focus of the lens; namely, on either side of the master positive and in contact with it, or directly in front of the duplicate negative raw stock, also in contact. If the matte is located in any other position, it will be out of focus in varying degrees, and hence a soft matte. Soft mattes may be placed at any point between the master positive and the duplicate negative raw stock, although it is customary to place them between the lens and master positive for operating convenience.

When sharp mattes are required, it is essential that they be placed upon film to be in contact with either the master positive or duplicate negative raw stock. They are made upon a high-contrast, clear-based film so that the black areas are opaque and the clear ones transparent, and are known as travelling mattes. There are a great number of transitional effects known as wipes, which move in a variety of directions and configurations, seen daily in television commercials and motion-picture trailers, and made by placing traveling mattes in contact with either the master positive or duplicate negative raw stock.

The soft-edge matte probably finds its greatest usefulness in visual effects such as having a scene appear that it is being photographed through a pair of binoculars or a telescope. A cut-out of the binocular or telescope field shape is placed in front of either the master positive or duplicating negative raw stock. Another is split-screen optical composite photography in which two scenes are blended together and appear as one. It is accomplished by placing the matte at a suitable location between master positive and lens, depending upon the degree of sharpness required of the matte.

There are other often-used, soft-edge transitional effects made by mechanically moving a "wipe-over" device interposed between lens and master positive.

The effects known as soft-edge wipes are identical with their hard-edge counterparts; however, the blend line between the two scenes is less sharp. The device may be replaced with another capable of placing traveling mattes away from contact position and therefore allowing a soft blend with a variety of the configurations available.

An optical printer admirably designed to perform the operations discussed in this paper with ease and flexibility is illustrated in Fig. 8. In addition, the machine possesses special features to facilitate their execution. Zooms, for example, are conveniently made since the focus and *f*-value automatically correct themselves as the camera is moved forward or reversed, thus keeping the film fully in focus and equally exposed. For this reason it is not necessary to either eye-focus blowups or compensate for exposure as the camera stays in focus and the lens iris opens automatically while the camera is moved into position.

Out-of-focus blowups can be created by moving the lens in or out of focus. The camera can be disconnected from the automatic follow focus by merely pressing a button, and moved independently, leaving the lens in position to create out-of-focus effects without enlarging the image.

The detachable wipe-over device is located between the master positive and lens. It will wipe in any direction at a variety of speeds, and since it has a wide range of positions between lens and master positive, any softness of edge is available.

The Projection Background Process

A further logical alteration in the optical printing arrangement of master positive, lens and negative raw stock yields a system known as the projection background process, shown in Fig. 9. The use of an additional or second lens

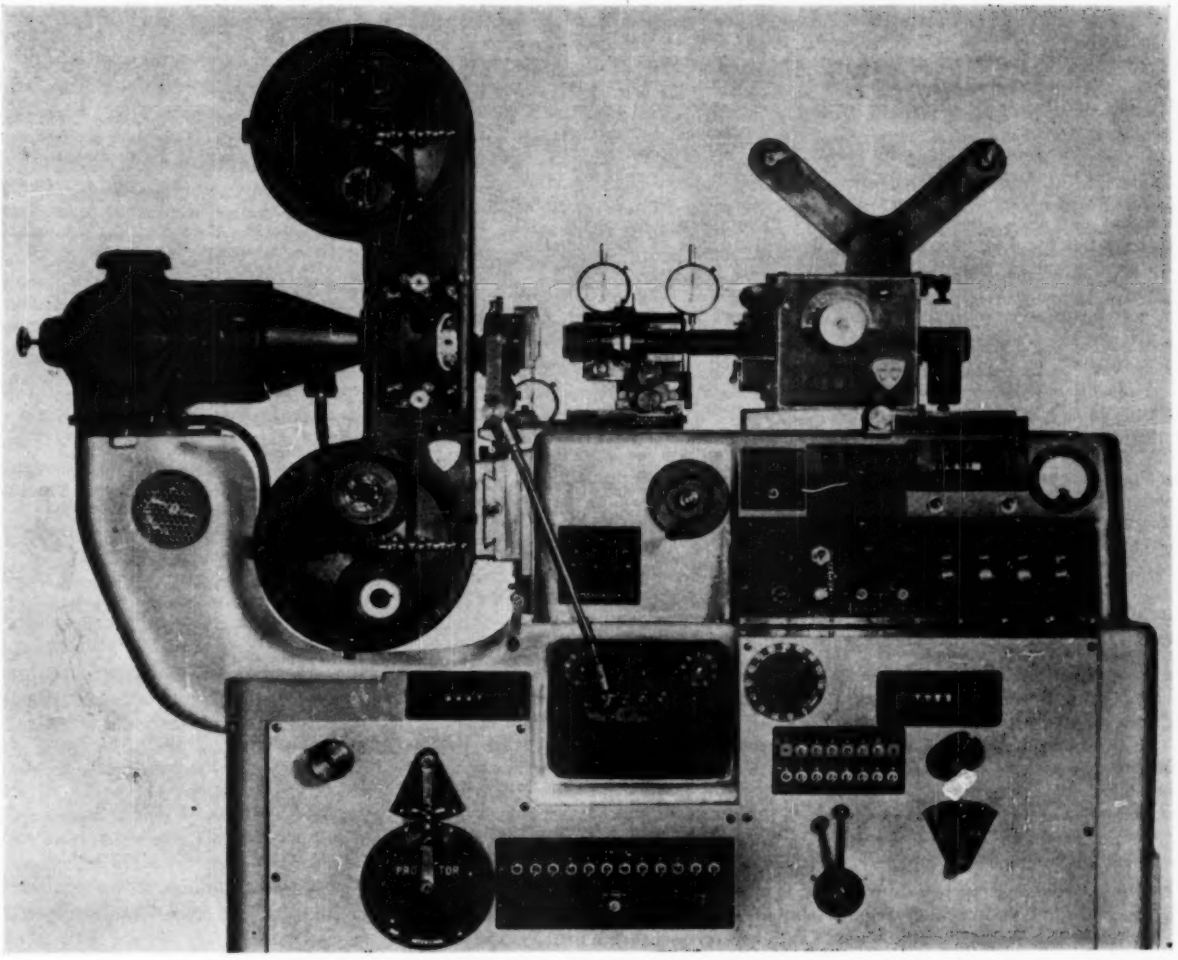

Fig. 8. An optical printer. (Courtesy of Producers Service Co.)

allows the master positive to be enlarged onto the back of a translucent screen. A conventional motion-picture production camera photographs the screen and the action taking place before it from the front.

The projection background process is an important, useful and sometimes even a necessary tool for motion-picture production. It serves to bring to reality many shots the writer assumes to be a hope or dream. Moreover, it relieves costly retakes as extraneous sounds sometimes are recorded in locations where noises cannot be excluded.

Although action takes place in front of the translucent screen, our interest lies in the fact that it is primarily a duplicating procedure and can be considered a full-scale example of composite photography. The foreground action mattes itself against the projected background and it is photographed or superimposed in a single operation.

The concept of having foreground action make its own matte while it is being photographed has been the basis for a number of patents issued in the field of composite photography. The

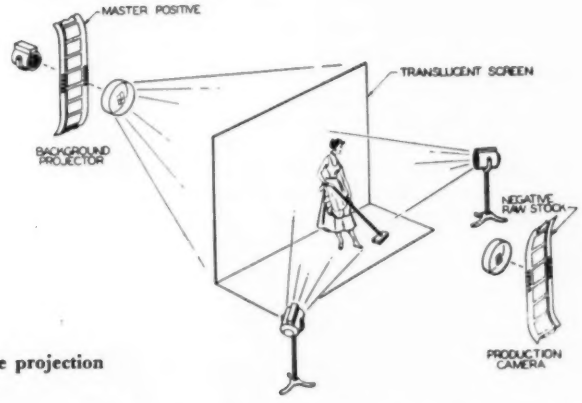

Fig. 9. Diagram of the projection background process.

two methods which enjoyed a great deal of favor until the advent of high-speed emulsions made the projection background process practicable, are the Williams Process and the Dunning Process. The latter is the work of C. Dunning and R. Pomeroy.

In the Williams Process, the action is photographed against a black background which yields a negative that is clear except for the action. Complementary mattes are made from the negative and it is combined with the background by either contact or optical duplication. The Dunning Process, based upon the separation of colors, places the foreground action in front of an illuminated, colored backing. The master positive is bleached and dyed a color complementary to the backing and placed in the camera in front of the negative raw stock.

Since both of these systems and all of their patented variations are limited by compositing the scenes using either contact or optical duplication, we shall confine our remarks to the projection background process.

As in optical duplication, the camera and projector movements are separate. It is essential to have a connection between them so that both films may be transported while the shutters are closed, and in photographing position when the shutters are open. On an optical printer this is accomplished by means of a driveshaft providing mechanical interlock between the two; in the projection background process, selsyn motors provide electrical interlock.

Accurate film registration is a basic requirement of the projection background process. If the master positive contains a stationary scene, any deviation throughout the system, starting with original photography through contact printing of the master positive and its projection, will immediately be apparent to the most casual observer. Lack of registration will cause movement in the composite between the foreground and background portions of the picture. The projector, as in other duplicating methods, possesses a full-fitting pilot pin so that the same perforation may be used throughout the process.

The problem of attaining an even field of the projected image as well as sufficient light to photograph it have long been engineering and equipment challenges to the industry. The even field has been obtained by altering the optical system of conventional lamphouses and projectors, and the use of arc light at ever-increasing amperages as well as the introduction of high-speed emulsions has allowed use of conventional interior lens aperture settings.

Special photographic effects promise to continue as a valuable element of motion-picture production. This paper has been limited to basic processes and their description by the evolution of the materials and equipment involved. In this way a thread has been woven into what is hoped to be a logical connection between the many optical effects performed by as many optical specialists.

The author wishes to thank Producers Service Co. and Mr. Jack Kiel of that organization for their assistance in preparing drawings and photographs.

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Foreign Language Dubbing

By MAURO ZAMBUTO

Dubbing, meaning postsynchronization, presents three problems: technico-artistic, technical and artistic. Several solutions are proposed and one universally accepted in Italy is illustrated. A good dubbing recording should match as closely as possible the sound quality expected in connection with the photographic image — resulting studio requirements are listed. Some features characteristic of the Italian language regarding structure of the audio signal, e.g. its average power distribution within the audiofrequency band, are listed and technical provisions to meet resulting requirements are analyzed. Some of the editing techniques adopted in Italy are described.

When motion pictures first began to talk there arose the problem of hurdling the language barrier and making the new product internationally marketable. To do this a method had to be devised to enable a foreign language audience to understand the action and get the maximum possible entertainment out of the picture. Naturally, this problem took on urgency for those countries whose national production was at the moment either insufficient for the local needs or nonexistent. Italy happened to be one of these countries.

Several methods were tried: (a) subtitling, (b) mixing a narrator with the original track, and (c) producing a foreign language soundtrack to match the original lip movements.

This last method would certainly provide the best conceivable solution if it could succeed in creating the impression that the picture was originally recorded in the language commonly understood by the audience.

In Italy subtitling proved unacceptable to mass audiences because reading distracted their attention from the action by adding an unnecessary strain.

As for the narrators, although they can be logical additions, can even be assets when the film subject is documentary in nature, experience proved them detrimental to an already filmed light comedy or an intense drama.

Therefore, in Italy, dubbing was and is the procedure universally adopted.

The very idea of dubbing has been criticized, sometimes even stigmatized on a theoretical basis and we are often asked why we prefer dubbing to all other techniques in Italy. I have only one reply to that: the Italian audience seems to be able to enjoy a foreign picture more when it is dubbed than in any other way and assuming the final aim of the industry to be that of providing the audience with the maximum possible entertainment, it stands to reason that we dub all foreign pictures into Italian. In fact, foreign films dubbed into Italian continue to compete successfully with the ever increasing number of good Italian language films made in Italy. Naturally, the considerable efforts made to improve the technique, the experience gathered in more than 20 years and the consequent excellence of the product are reasons for such a result.

The question now arises: "What constitutes good dubbing?" And the condensed answer is: "The Soundtrack should sound like what the audience expects to hear in conjunction with the on-screen action over such a wide field of characteristics as ambiental acoustics, presence, lip synchronization, voice quality, emotional content, etc.

This gives rise to a number of problems which may be grouped as follows: technico-artistic, technical and artistic.

Presented on April 24, 1952, at the Society's Convention at Chicago by Mauro Zambuto, Technical Director, Scalera Films, Rome and Venice; c/o Italian Films Export, 1501 Broadway, New York 36.
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It is the aim of the present paper to illustrate some of the procedures adopted in Italy to solve these problems.

Technico-artistic Problems

These concern achieving the best possible lip synchronization.

In order to obtain good synchronization the script must use words and sentences that will match the length and the lip movements of the original lines.

At the same time, it must be written in fluent, colloquial language, it must retain the spirit and emotional content of the original script and it must take into account the tastes of the audience it is meant for. Thus, the script should not be a mere translation, but rather an adaptation; for instance: varying idioms and varying customs being what they are, a joke which sounds uproariously funny to an American audience may mean absolutely nothing to an Italian audience, so the scripter must devise another joke which will sound just as funny to the Italians and will still be pertinent to the action.

There are no infallible rules for this part of the job. It requires a combination of training and intuition. The general procedure is to draw up a first translation which roughly approximates the length of the original lines, and thereafter to work on it line by line, watching the picture on an editing machine and deciding on the degree of precision necessary in relation to position of the actor, distance of the actor from the camera, amount of general illumination of the subject, off-screen lines, etc.

Another technico-artistic problem concerns the actual recording. How can the actors be put most simply and effectively in a position to deliver their lines in synchronization, without losing the required excellence of performance? Here again, several methods were proposed. Most of them entail the synchronous projection of a band on which the words are written and/or an oscillogram of the original track is reproduced. Some others entail the marking of the photographic image with dots, lines, start marks and visual cues of various types to help the actor in the timing. All these contrivances have been tested and discarded in Italy mainly for one or both of two reasons:

(1) It must be remembered that good lip synchronization alone is not sufficient to insure good dubbing. Good delivery of the lines, as specified under "Artistic Problems," below, is at least as important.

(2) Lip synchronization is achieved not only by matching the "length" of the original line, but, even more important, by using the same rhythm in delivering it. For example, ten syllables (in the sense of ten lip movements) can be crammed into the time it took the original actor to articulate three lip movements. The length of the original line would thus be matched by the dubbed one in the respect that when the on-screen actor starts and stops lip motion, the sound starts and stops simultaneously, but the difference in rhythm would be disturbing, unintentionally humorous, or downright irritating.

Now experience has proved that each and all of the above-mentioned systems either negatively affect performance, or do not provide accurate rhythm, or both.

The procedure now universally adopted in Italy is the one generally referred to as "looping" and very well known in this country.

The film is cut into short sequences. The top and bottom ends of each of the resulting small rolls of film are cemented together so that a loop of film is obtained and the sequence may be projected any number of times with no time lost to reload the projector. The loop is shown to the actors doing the dubbing. They stand in front of the screen and start rehearsing their lines. When they have mastered the rhythm of the original performance the sound is cut off and switched over to earphones. The actors go on rehearsing to improve synchronization and performance. They look at the screen and at the same time listen to the original track through the earphones. When the director is satisfied, the sequence is recorded.

The use of earphones may seem a nuisance to the beginner, but it is really of the greatest value, because it automatically keeps the dubber on the rhythm of the original performance.

Artistic Problems

These concern achieving a delivery of the lines that will sound natural and convey the required emotions to the audience.

This is mainly a matter of selecting and coaching actors. As to selecting the actors, the director must judge carefully. It is in fact a question not only of selecting the proper voices but also of choosing the proper temperaments. Some extremely fine actors are, unfortunately for dubbing purposes, possessed of such highly individualized styles that they can be used only when these harmonize with the original characters portrayed. Other dubbers are possessed of such flexibility that they can adapt to a wide range of characters and can easily match another actor's interpretation. As actors the latter are not necessarily as good as the ones first mentioned, but they are better suited to dubbing.

This question of matching interpretation is extremely important. In fact, a diction and feeling which would rate applause if heard separately could sound terribly phony when matched to the action of the original on-screen actor.

This is why any method that will divert the dubber's mind from the scene on the screen is objectionable. Even if it helps synchronization it will break the chain that must link the dubber to the actor, the voice to the action.

Yet the dubber's performance must not be identical with the original one. Since every language is endowed with peculiar cadences and inflections, the new interpretation must translate the feeling portrayed by the picture in terms of these cadences and inflections rather than just duplicate the original interpretation. This, together with the requirement of not jarring with the original interpretation, may sound rather difficult to work out, but it is astounding how well some actors, given the necessary experience, will meet these requirements.

As far as the solution of this problem is concerned, there is no substitute for the combined experience of the director and the dubber.

Technical Problems

The production of a good dubbed track presents a great number of technical problems but in this paper we will touch on only some of them.

The first problem is one of architectural acoustics. The audience expects a sound quality that will match the conditions depicted on the screen with regard to presence, reverberation, etc.

In theory, if the recording of the dubbing were made in a perfectly absorbent studio, it would be possible to match any condition whatsoever during re-recording by the use of an echo chamber together with the proper phasing filters and frequency equalizers both in the direct and in the echo channels.

In practice this is not feasible for two major reasons:

(1) A simple analysis of the characteristics required of the three elements involved (echo chamber, phasing filters, frequency equalizers) to meet some of the possible requirements, will show that these characteristics are scattered over so wide a range that it would be practically impossible to devise solutions that would cover all of them economically.

Certainly any good mixer knows that he can do amazing things to the quality of a soundtrack by just setting in the required amount of equalization and reverberation, but the same mixer will tell you that there is also a limit to what he can do, and anybody who has ever tried to translate into practice even the simple theoretical truth that presence is the result of the ratio of direct to reverberated sound knows exactly where these limitations set in.

(2) A second reason is that none of us will use the same tone of voice when saying something in a quiet room, in a crowded and noisy hall or in a wide open space. Consequently the way the dubber utters his lines will be affected by the way he hears his own voice during the

recording, that is, by the acoustic characteristics of the dubbing stage.

Set him in a live scoring room and you will get a totally different voice and performance than you would if he were in a small, highly absorbent enclosure. So the recording stage should put him into acoustic conditions as closely as possible approximating those of the actual set.

All efforts in this direction have led to the construction of a sound stage having movable panels on the walls. Reverberation times of from 0.5 to 1.5 sec and decay curves having a wide range of shapes may be obtained in such a stage. Also different frequency-response characteristics in the reverberated sound may be easily obtained, provided the studio is sufficiently large. Of late, setting resonant boards and boxes, generally of plywood, in the set has been attempted, but this technique is still in an experimental stage, though it is sound theoretically.

As far as presence is concerned, a number of microphones are used and switching arrangements are provided on the mixing console. For tracking, a microphone on a boom will generally give the best results. The technique of mixing the output of differently spaced microphones fading one in and another one out has given astoundingly good results in getting tracking effects when proper selection of microphones, microphone positions and phasing is assured. Such technique, however, is admittedly complex and requires a skilled operator with a long experience of the particular sound stage and microphones he is using.

In this brief account of some peculiarities of sound recording, as practiced in Italy, I would like to mention the fact that the most suitable frequency-response curve to be used in recording depends on the language to be recorded.

In comparing the Italian and English languages we note that under the same general conditions a greater amount of dialogue equalization should be used in recording Italian. On the other hand, Italian will permit much less mid-frequency equalization than English and it requires practically no de-esser in the compressor circuits. Optimum compressor attack time is shorter and release time longer. Greatly improved results are obtained by using a compression frequency response approximating the normal audiogram curve for about 40 phone.

The reason for all this is that the average power distribution in the audio-frequency band is not the same in Italian as in English. In fact, it has a definite peak in the region of 1500 cycles and a flex in the region of 800 cycles extending to 400 cycles. This is for the average level of normal conversation. Shouting has the usual effect of cutting low frequencies while whispering decidedly increases high frequencies.

An analysis of the consequences of such discrepancies, being very detailed, is beyond the scope of this paper. We hope to go into such detailed analysis in a paper now being prepared for publication describing recent experiments in this field.

Incidentally, these experiments led to the definition of an "average form factor" only the order of magnitude of which is measurable and has physical meaning.

The rather great discrepancy of average form factors between the Italian and English languages seems to account for the difference in optimum setting of compressor characteristics. In fact the whole series of experiments just mentioned sprang from the wish to justify the observation that a different setting was desirable for recording the two languages.

Distinctive problems also arise in editing the dubbed track. The necessity of making critical corrections to the synchronism of parts of the lines, sometimes of single words, gives rise to practical difficulties which were emphasized by the advent of magnetic recording. Here again many techniques are being tried to speed the editing of the tracks and emphasis is set on economy of stock, as this is an important factor in Italy.

In this respect, each studio in Italy is using a different technique. Procedures range from the recording of a direct positive to the re-recording and editing of a negative which is then used for the final mixing without printing, by means of a special amplifier. Other methods entail the direct editing of the perforated-tape magnetic track or the re-recording of the original magnetic track on a second tape during the editing.

A detailed account of these techniques and a description of the equipment used in the actual procedure would overshoot the limits of the present paper, the aim of which is only to acquaint American technicians with some of the problems connected with a very particular procedure which has been used in Italy for over 20 years and with the way in which Italian engineers are meeting these problems.

Discussion

George Lewin (Signal Corps Pictorial Center): Have you ever done any work with playbacks when you do your looping operation and, if so, what value do you think they have?

Mr. Zambuto: When you say playback, do you mean the usual technique used for scoring of songs, namely producing the soundtrack first and then shooting the picture in synchronism with a playback of it?

Mr. Lewin: No, I mean when you're doing the loop, do you have facilities so that as soon as you've made a take on the loop you immediately play it back and judge whether or not it can be improved?

Mr. Zambuto: Practically all our studios have these facilities, particularly since the advent of magnetic recording. This is obtained in two different ways. We can cut — the magnetic raw stock — in loops of the same length as the original loop and record on them and then, of course, reproduce at will in synchronism because the picture loop and the magnetic recorded loop are interlocked and of the same length. This procedure was used in the beginning for quite a long period, but has now been superseded. Now we record on normal reels and whenever we want to listen back we go back to a crayon start mark that is made just before the recording and run the projector and the recording machine in interlock.

However, the need of taking the time to listen back to what has been recorded to check on synchronism and performance may arise only very occasionally in Italy. Actors and directors of dubbing there are so experienced that they will generally be able to tell, by what they have seen during the recording, whether the take is usable or not. So we seldom have to use this contrivance to listen back. But we certainly are equipped for it.

Charles R. Daily (Paramount Pictures): It has recently been suggested that it might be cheaper to send abroad a double soundtrack film for subsequent recording. One half-width track would carry the music and effects, while the other would carry the English dialog. What is your opinion of this system when used in making up the Italian dialog version?

Mr. Zambuto: What is meant exactly by "double soundtrack?"

Dr. Daily: One form of the double track would be to combine the music and effects on one track with the dialog on the other. The dialog track would of course contain some effects under dialog that cannot be separated.

Mr. Zambuto: Well, it would certainly be an economy in film and shipping cost. Of course, it would make things a bit more difficult for us at the stage of final mixing, because in fact we would be using a narrower track and that wouldn't improve our signal-to-noise ratio in any way. But there is another problem. The original print made from the dupe negative that you send over is cut into loops for dubbing and then is again spliced together to make up the original length. We sometimes even have to add little pieces of leader. We couldn't possibly use that particular print to make our re-recordings because it would have to be blooped, and sometimes even the blooping wouldn't be possible. Therefore if you send that kind of dupe, while you would save money on printing a separate music and effects track on a separate film, we would still have to make an extra print in Italy.

Mr. Lewin: I'm very interested in that method you say you have which makes it unnecessary to cut the film. Could you explain briefly what that is?

Mr. Zambuto: Yes, it has been developed only recently and is in an experimental stage. It is, in fact, a sort of film editor. To edit our recordings, the normal procedure would be to find the start marks, cut out the required strips of film, then splice them together to make up the full reel. All stock edited in such fashion could never be used again. The new editor has a very good reproducing head and we also have a recording head on a separate channel. This can re-record on new tape the output of the reproducing head. We have amplifier facilities that will keep the gain constant, so that a perfect duplication of the original recording can be obtained, without having to control levels.

Our aim is to transfer from the original reel to the new reel only the parts we want and in the positions where we want them for synchronism. To do this, whenever we want to put a start mark we apply a little chip of film at the proper place on the original tape and another one where we want to stop. Then we match start marks on the original track on the picture and on the raw stock on which we are going to transfer. We run the machine back, just to give it time to get to speed, and then we run the picture and the two tapes in interlock. No recording is made until the first chip we have applied trips a microswitch. Whatever comes after that in our original recording is recorded on the other tape which is running interlock. When the second chip trips the microswitch the sound is cut and we can repeat the procedure over and over again until all the reel is recorded. This is a very rough way of putting it, but I hope I have given some idea of how it is done.

The Problems of Control of the Color Photographic Processes

By ALLAN M. KOERNER

The control of continuous processes requires four distinct operations: (1) establishment and specification of the desired levels, (2) continuous evaluation to determine whether specifications are being met, (3) diagnosis when they are not met, and (4) taking corrective action. How each of these four operations are conducted in the Eastman Kodak Co. in controlling the Kodachrome processes is discussed, and it is indicated that these procedures may have application in the control of these or other processes elsewhere. Precautions to be observed and some of the principal causes of poor control are also indicated.

THIS PAPER will discuss some aspects of the problem of control of those color photographic processes in which large quantities of film are being continuously processed. The quantities of film are so large that various batches or emulsion numbers of the product are being handled at the same time. The Eastman Kodak Co. as well as other film manufacturers have been faced with this problem in the manufacture and processing of 16mm amateur motion-picture film and 35mm slide film. In these processes, thousands of short lengths of film of almost random emulsion numbers are spliced together and processed as a continuous length. In the United States, processing of amateur Kodachrome film by the Eastman Kodak Co. is done in any one of seven locations on any one of many processing machines. The problem, then, is to present to the customers a result which is uniform from processing machine to processing machine, from processing laboratory to processing laboratory, and from customer to customer.

The amateur Kodachrome process is a single-cycle process. The film is manufactured and tested; it is shipped to the customer who exposes it; then it is processed and returned to the customer who views the results. There is something very final about this. When the film comes off the processing machine there are no additional steps that can be taken to correct for an error that has been made.

There are other color processes that involve more than one cycle. In a two-cycle process the first cycle will be concerned with the production of a negative or a reversal original, and in the second cycle a print from either this negative or original will be made. There are also three- and four-cycle processes involving intermediate negative or print stages. These may be required for the production of special effects or perhaps simply to avoid subjecting the master original to the rigorous wear and tear that is involved in the making of many copies. Eastman Color Negative and Print materials are always used in applications which involve more than one cycle.

It would appear that in multicycle processes the situation is different and if a mistake is made in the first cycle, some compensating adjustment can be made in a following one. It will be pointed out later that the flexibility which results from this consideration is somewhat less than appears on the surface, and these processes also require a high degree of control in all phases if the final product is to be consistently right.

The problems of control have been increased many fold with the advent of color since in color films we are faced with the maintenance of uniformity of processing in not just a single emulsion layer but in three layers, *in* each of which and *between* each two of which a very delicate balance must be maintained if the pictures are to be uniform. At the Eastman Kodak Co. a large effort has gone into a study of control problems in color processing. Most of the concepts that have come out of this study are exceedingly simple and self-evident. On the other hand, experience has shown that in those instances where difficulty has been encountered in controlling a process, it has been because of the failure to observe one or more basic principles of control and the failure to recognize the true nature of these processes.

A discussion of this problem is considered timely because processing of various color films is being undertaken on an increasing scale by commercial laboratories throughout the country. Hanson and Kisner* have described some improvements in Eastman Color Films, designed for customer processing, and the processes involved. In operating these and other color processes the laboratories will undoubtedly encounter some of the problems that have been faced by Eastman Kodak Co. in the handling of Kodachrome films. It is expected that many of the principles and methods that have been employed will find direct application in these other processes.

Presented on April 30, 1953, at the Society's Convention at Los Angeles by Allan M. Koerner, Color Control Div., Eastman Kodak Co., Kodak Park, Rochester 4, N.Y.
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* W. T. Hanson, Jr., and W. I. Kisner, "Improved color films for color motion-picture production," *Jour. SMPTE, 61:* 667–701, Dec. 1953.

Essential Phases of Control

The control of any process, photographic or otherwise, comprises four distinct and essential phases. First, there must be a knowledge of the desired characteristics of the process and the product; second, there must be a continuous evaluation of the status of the process to determine whether these characteristics are being maintained; third, there must be diagnosis and the location of trouble when the evaluation indicates that the characteristics are not being maintained; and finally, the proper corrective action must be taken after the trouble is located. All four of these elements must be present in a process control system, and the omission of any one of them is likely to lead to trouble. These phases as they apply to the color photographic processes will be discussed in some detail in the paragraphs that follow.

Specification of the System — How Accomplished — Why Necessary

Kodachrome film can be manufactured and the Kodachrome process can be run in any one of an infinite number of ways so that the picture the customer receives will appear predominantly blue, or predominantly green — or red. It is obviously desirable to make the film and to run the process so that to the customer the picture will appear just right. It is therefore essential to establish the characteristics of the most desirable pictures, from the customers' standpoint, that can be obtained with the product. At Rochester the optimum picture for these amateur processes is arrived at by having a large group of people view and choose among pictures which differ from each other because of deliberately introduced variations in color balance, contrast and other characteristics. Since the particular color balance or contrast level chosen by these people will often depend on the type of scene represented in the photograph, it is necessary to use many scenes in this work. However, in actual operation it will not be possible to change the process either from scene to scene or from customer to customer, so the problem becomes a statistical one of trying to satisfy the largest number of custom-

ers, taking into account the types of scenes which they are likely to photograph.

Having found the pictures which seem to be optimum in this respect, two additional steps are taken. First, the particular processing conditions which produced them are considered as the standard conditions for the process. These are listed and described in detail and become the specifications for the process wherever it may be operated under the control of Eastman Kodak Co. Similarly, the particular film on which the optimum picture was produced is considered the standard film and it too is described in detail. Second, the optimum pictures are defined in terms of sensitometry. Strips of the standard film, exposed to a gray scale in a carefully controlled sensitometer, are processed in the standard process. From these strips a numerical description of the optimum photographic result can be obtained by means of a densitometer. Thus the standard process is specified in two ways: first, in terms of how it is to be operated; and second, in terms of the results it is expected to yield.

In this operation of setting process specifications there is a transition from pictures to chemistry. The process is established in terms of various chemicals, processing times and temperatures, mechanical conditions, etc. In other words, while "pictures" is the end, "chemistry" is the means. Furthermore, the chemistry is divided into two parts, one part in the film and the other part in the processing solutions. The final picture is only the result of bringing these two chemical parts together. It is quite clear, then, that the specifications must include both the film and the process and that the two are inseparably related. Failure to recognize this fact has often led to trouble for the following reason.

In the manufacture of a single batch of color film a vast number of tests are made. Some of these are physical in nature and others are chemical. However, there are no tests of the *unprocessed* material which are in themselves sufficiently discerning so that by means of them alone the quality of the final product can be predicted. The final test of quality always involves putting the material to use. Samples from every batch of film are exposed in a sensitometer and processed, and the final decision as to whether the material is salable product or waste rests on an evaluation of the processed film. Therefore, in the most important and only really decisive test which the manufacturer makes of his film he must assume that he knows what the chemistry of the customer's process is going to be. If his assumption is wrong, then his test is no longer valid, and the protection provided for the film customer is decreased.

It is for this reason that multicycle processes are not really as flexible as they might appear to be. It is true that if a processing mistake is made which results in a negative which is off-color, a compensating adjustment in the color of the filters used in the printing operation will afford a degree of correction. This procedure is necessary in those rare cases where an accident has occurred and where the material must be salvaged. However, if it becomes a rule rather than exception that the chemistry of the customer's process is permitted to differ greatly from the manufacturer's process, the results may be unpredictable. While pictures on one film may appear to be satisfactory, the films in general will not perform as predicted by the manufacturer's tests. The way in which they fail will vary from emulsion to emulsion, and it will be impossible to find a compensating adjustment which can be made in the printing, or elsewhere in succeeding cycles, which will apply to all emulsions. In both single-cycle and multicycle processes, if the final product is to be consistently right, then every step in the overall process must also be right and be operated in a controlled fashion.

To summarize, the need for a rigidly specified system exists because color-film manufacturers are not yet able to make film that is identical in every respect from batch to batch. They can manufacture film that is quite uniform within the rather restricted framework of a single chemical process. In order that the product appear as uniform to the customer as to the manufacturer, it is essential that the customer's processes conform reasonably well to the specifications.

Methods of Process Evaluation

The second phase of control calls for the continuous evaluation of the process to determine whether specifications are being met. It has been pointed out that the process is specified in two ways: first, in terms of photography, and second, in terms of chemistry. The evaluation, too, must be dual in nature. The necessity for two systems of evaluation arises out of the inability of either one of them alone to give a complete story.

The method of chemical analysis of processing solutions is inadequate if used alone because the processes are so complex that it is impossible to specify them completely in chemical terms.

The photographic method of evaluating a process by means of exposed and processed film is inadequate because it cannot by itself guarantee that the chemistry is being held constant. One off-standard condition in the chemistry may be partially compensated, so far as the pictures on one emulsion are concerned, by the introduction of another off-standard chemical condition elsewhere in the process, but there can be no assurance that the alteration in the chemistry will work for other batches of film.

The evaluation of a process by photographic strips alone is inadequate for another reason. There are certain cases where the effects of a nonstandard condition in the process are not immediately apparent in photographic strips, but become apparent later on. For instance, the stability of the dye images in processed color film that is kept for some time is highly dependent on the amount of hypo that remains in the film after processing. Yet the appearance of the freshly processed film gives no indication when hypo reaches a dangerous level. This can be determined only by chemical tests.

While it has been concluded that the evaluation of Kodachrome processes by means of neither chemistry alone nor sensitometric strips alone is adequate, it has at the same time been found that a combination of the two, if applied with a great deal of care, will provide a pretty clear statement of the condition of the process.

In processes operated by the Eastman Kodak Co., chemical analyses of many of the constituents of the solutions are routinely made. For the most critical chemicals — those where a small change in level will produce a large photographic effect — the analyses are run as frequently as once per eight-hour trick. For less critical components they are run as infrequently as once a week. At the same time, sensitometrically exposed strips of film are processed hourly on each of the machines.

Both methods of evaluation must be operated with extreme care if they are to give valid results. The performance of the chemical analyses should be supervised by a trained analytical chemist. Poor analyses are worse than none because they breed a degree of confidence which is unjustified. Methods of analysis for almost all the critical chemicals used in Eastman Kodak Co. color processes have been compiled, and detailed instructions for their operation are available to those who use these processes.

While chemical analyses assure the maintenance of a stable process over long periods of time, the photographic strips give an hour-to-hour assurance that no unsuspected accidents have occurred to move the process away from standard. But sensitometry must be administered with meticulous attention to numerous details if it is to be effective. In applying sensitometry to the evaluation of processes, certain critical assumptions are made. Among these are the following:

(1) that the exposures made in the sensitometer are identical from strip to strip;

(2) that the film on which these exposures are made is uniform throughout its length;

(3) that the film is stable with time;

(4) that the exposures are a close ap-

proximation in duration and quality of light to those encountered in actual use of the material; and

(5) that gray scales as an abstraction of picture quality, are adequate for control.

In the following few paragraphs the validity of each of these assumptions is briefly discussed.

(*1*) *Assumption of Identity of Exposures From Strip to Strip.* Since the processed sensitometric strips are to be used as a means of detecting variations in the process, it is quite clear that all other variations inherent in the strips that might affect the photographic result must be reduced to a minimum. The exposure operation is one stage in which unwanted variations can easily occur. To avoid such deviations, rigid regulation of the power supply to the exposing light source is essential. It is axiomatic that inadequate electrical contacts must be avoided and electrical connections should be rigidly soldered wherever possible. The mechanism which determines the length of exposure must be precise and capable of reproducible exposures. Adequate uniformity can be obtained by using a swinging pedulum mechanism to control exposure time as is done in the Eastman Processing Control Sensitometer or by means of a constantly rotating drum driven by a synchronous motor. The latter method is used in the more complex Eastman Intensity Scale Sensitometer Automatic Type Ib (Fig. 1) which serves as the primary standard instrument for control of the Kodachrome processes. Since it is easier to maintain a sensitometer constant over a short period of time, it is desirable that it be capable of exposing many strips in a short interval. These will then be stored to be used as needed. The maintenance of a sensitometer is always critical, and if possible frequent checks against a standard instrument should be made to insure constancy of exposure.

(*2*) *Assumption That the Film Is Uniform Throughout Its Length.* This is perhaps the most valid of the assumptions listed above, so long as one continuous length of a single batch number is used. The manufacturer does not, however claim to maintain an adequate constancy for the sensitometric evaluation of processes if different batches of film are used interchangeably. It is therefore essential that film to be used for sensitometric purposes be carefully identified and inventoried so that the possibility of intermixture of different batches is avoided. When the supply of a particular batch has been depleted, and a new one must be used, careful revisions of the photographic standards must be made recognizing the differences between the batches.

(*3*) *Assumption That the Film Is Stable With Time.* This can perhaps be the most insidious of the assumptions. Film is not, under ordinary conditions of temperature and humidity, precisely constant. As it ages many of its characteristics gradually change. Furthermore, after it has been exposed, the latent image changes with time. This was a serious problem in the control of the Kodachrome processes until use was made of the modern deep freeze refrigerator for storage of control films. All check films for use in the Kodachrome process are now stored at temperatures of 0 F, or lower, prior to processing. At zero or below, the changes in the film itself and changes in the latent image are sufficiently arrested for process control purposes. It is only if such storage conditions are provided that many sensitometric strips can be exposed at one time for use later on, as was suggested in the preceding paragraph.

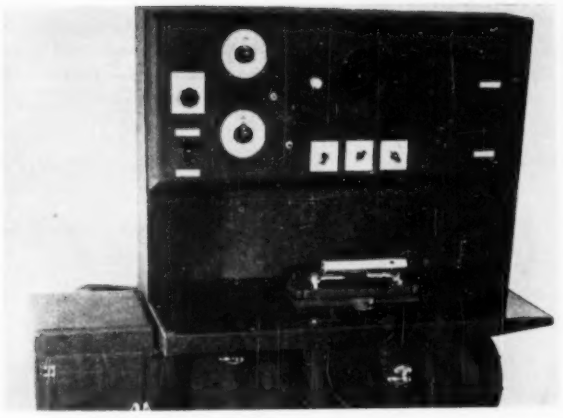

Fig. 1. Eastman Intensity Scale Sensitometer, Automatic Type Ib, Model IV.

(*4*) *Assumption That the Exposures Are a Close Approximation to Those Encountered in Actual Use.* The quality of light used in making the exposures and the exposure times must closely approximate conditions encountered in actual use of the material. Such characteristics as contrast and speed of the individual layers in color films can vary considerably depending upon exposure time. In other words, the characteristic curves for a film in which an exposure time of 1/10 sec was used may differ appreciably in configuration from curves on the same material exposed at 1 sec and may differ even more greatly as the ratio of exposure increases above this 10-to-1 figure. Furthermore, process variations may affect a film exposed at 1/10 sec in a very different manner from that in which they will affect a film exposed for 10 sec. Using vastly different exposures from those encountered in practice, either timewise or colorwise, is as serious a mistake as using for sensitometric control a film entirely different from the one which will be routinely processed. For instance, Kodachrome Duplicating Film cannot be used to evaluate sensitometrically a process in which Kodachrome Commercial Film is to be handled because the two products will react differently to process variations.

(*5*) *Assumption That Gray Scales Are Adequate for Control.* As has been pointed out, sensitometric procedures provide a means of expressing photographic results in terms of numbers. Sensitometric strips are usually exposed to a gray scale only, or at most to a gray scale and a few color patches. In this sense then, sensitometric exposures represent an abstraction of the total information that is contained in a color photograph. The extent to which the information is abstracted can be increased or decreased depending upon how many density steps are included in the gray scale and how many color patches are used. Very often color patches are omitted altogether.

If a fairly large number of steps (say 20) are used in the gray scale, it is possible by means of color densitometry to construct characteristic curves which approximate the exposure-dye relationships in each of the three layers of the processed film. How this is done and the assumptions that are involved in the procedure are described in "Principles of Color Sensitometry" of the SMPTE Color Sensitometry Subcommittee.* A set of typical characteristic curves of this type is shown in Fig. 2.

Now it is quite obvious that as the number of density steps in the gray scale is reduced, the degree of certainty with which such curves can be drawn is also reduced. On the other hand, where as many sensitometric strips are processed as is the case in the Eastman Kodak Co. Kodachrome processes, it is out of the question to measure as many as 20 steps for the construction of such curves. Indeed, it is impractical to plot characteristic curves at all for the vast majority of these strips.

There is no completely satisfactory solution to the problem. In the Kodachrome processes about six separate densitometric readings are taken from each of the control strips. By simple calculations these readings are converted

* See *Jour. SMPTE, 54:* 653–724, June 1950; also in reprint form.

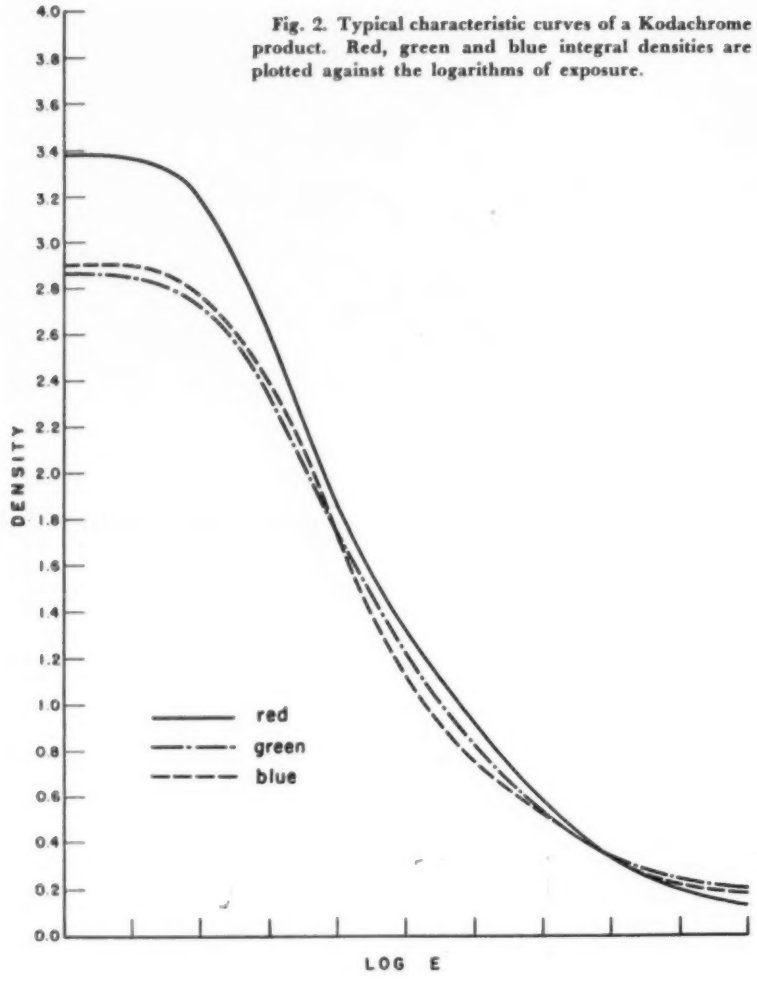

Fig. 2. Typical characteristic curves of a Kodachrome product. Red, green and blue integral densities are plotted against the logarithms of exposure.

into numbers which roughly approximate such characteristics as speed, color balance and contrast. These numbers are then plotted on control charts on which standards and tolerances for each of the characteristics are clearly shown. Since it is realized that these numbers represent a great abstraction of the information contained in a color photographic picture, once a day a complete set of curves from a 21-step gray scale (63 densitometric readings) must be plotted and examined to detect any deviations from standard not revealed by the abstracted indices. Furthermore, the existence of sensitometric control procedures does not eliminate the necessity for frequently looking at pictures. In a well operated control system, the trend in picture results will seldom differ from that of the sensitometric results, but it would be sheer folly to assume that no error can occur in sensitometric evaluation and hence that pictures need not be viewed.

For purposes of process control alone, sensitometric evaluation is essential. Over and above this, sensitometry is the language of photographic technology. It is only quite recently that color photographic films that can be handled in relatively simple processes have been made available. Some of these products have already been replaced by newer and better ones. These, of course, are not the ultimate, and efforts to improve them will continue. This improvement will be hastened if the common language of sensitometry can be employed by manufacturer, processor and consumer in evaluating photographic results.

The Location of Trouble and Its Correction

If the diagnosis and location of trouble is to take place promptly, it is desirable that the data derived from chemical analyses and photographic test strips be plotted in the proper time sequence on a control chart. The control charts should show the standard levels as straight horizontal lines around which the actual readings will be plotted. In addition to the standard levels, the permissible tolerances should also be shown (Figs. 3 and 4). In Kodak laboratories, when the photographic tolerances are exceeded, customers' film must be removed from the machines until the source of the difficulty can be located. Abrupt changes in photographic results are rare. Drifts or trends away from standard are much more likely to occur since the processes have considerable inertia because of the large volumes of solutions involved. By watching for trends, corrections can usually be made considerably before the tolerances are reached.

As soon as a definite trend in photographic results has been observed, the corresponding chemical data are critically examined and extra analyses may be called for. In the term "chemical data" are included such items as temperature of the processing solutions, machine speeds, solution agitation, etc., each of which has a critical effect on the chemical reaction. As a rule, in well controlled processes some abnormality in chemical levels will be found which will correlate with an off-standard photographic result. If no such abnormality is found, then some solution contaminant which is not regularly analyzed for must be suspected.

In other words, since the photographic processes are largely chemical in nature, the sources of control difficulties must most frequently be sought in the chemistry. It has been found that the most important causes of variations in the color processes are these:

(1) *The Use of Impure Chemicals.* This is too obvious to require extensive explanation. The corrective action required is also obvious. With the exception of a few of the inorganic compounds, no chemicals are permitted to be used in Eastman Kodak color processes until they have been certified. Certification is based partially on the results of chemical analyses, but finally on the basis of an actual use-test run in a small processing machine. Chemicals that this company sells for color processing have been similarly certified.

(2) *Improper Replenishment Formulas.* The processing solutions in Kodachrome processes are continuously maintained by the metered flow of replenisher solutions which replace those constituents being used up by the photographic process. This is the only way in which a process can be maintained in control in the strictest sense. A process which is constantly drifting toward depletion and is then restored to its original levels by occasional "shots" or additions of chemicals is not in such control. It has been found possible to adjust replenishment rates in the Kodachrome processes to such a degree that the prescribed chemical levels have been maintained for intervals of several weeks of continuous processing without any further chemical additions. Obviously, if the replenisher formulas and rates are not properly balanced, a stable system will not be attained. It should be pointed out that most metering devices for measuring liquid flow require

occasional recalibration. If drifts in chemical levels recur, the calibration of devices for measuring replenisher rates should be suspected.

(3) *Improper Storage of Replenishers.* All of the care that can be exercised in the preparation of replenishers will be of little avail if they are permitted to deteriorate during use. They must be properly stored to prevent decomposition. The single most important factor in maintaining replenishers at their original chemical levels is the exclusion of air, and as simple a thing as floating covers for the tanks in which they are stored can increase the useful life from a few hours to a week. Aeration of replenisher solutions during the mixing operation should be studiously avoided. Since heat is also a cause of rapid deterioration, it is now normal practice to mix some of the most critical Kodachrome replenishers at water temperatures of about 40 F.

(4) *Contact With Active Materials During Storage or Use.* Certain types of plastics which are being used more and more frequently in processing applications are not inert with respect to processing solutions and will cause them to deteriorate. Various metals, especially copper, also fall in this category.

Statistical Nature of the Control Problem

In an earlier paragraph it was stated that in a well operated process the trend in picture results will seldom differ from that of the sensitometric results, and it was implied that for every trend in sensitometric results a corresponding change in chemistry could be found. It must be emphasized that this is true only if the sensitometric and the chemical data are viewed with a statistical attitude. It will not be found true in every case if the results of single sensitometric tests or single chemical analyses are taken as absolute measures of process level.

Just as a machinist must always remain aware that measurements to less than 0.0001 in. cannot be reliably made by means of ordinary micrometers, so must the process-control man also be aware of the capabilities of chemical analyses and sensitometric strips in measuring process performance. There is a certain inherent variability in the chemical analyses of, and photographic results from, processing solutions which are as nearly identical as they can be made. To assume that no such variability exists will lead to over-control of the processes. That is, corrective action will be taken when it is not justified. Such over-control results in more rather than less variation in results.

That this inherent variability exists can readily be shown by making a large number of sensitometric exposures end-to-end on one continuous piece of film and processing this film at one time.

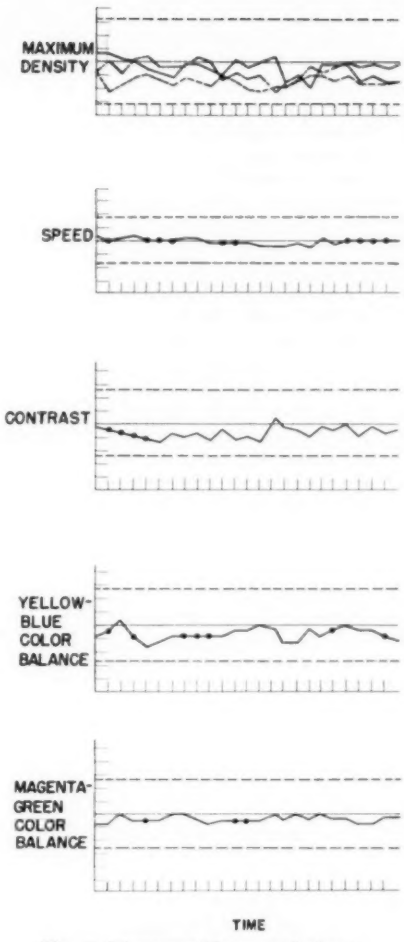

Fig. 3. Photographic control chart.

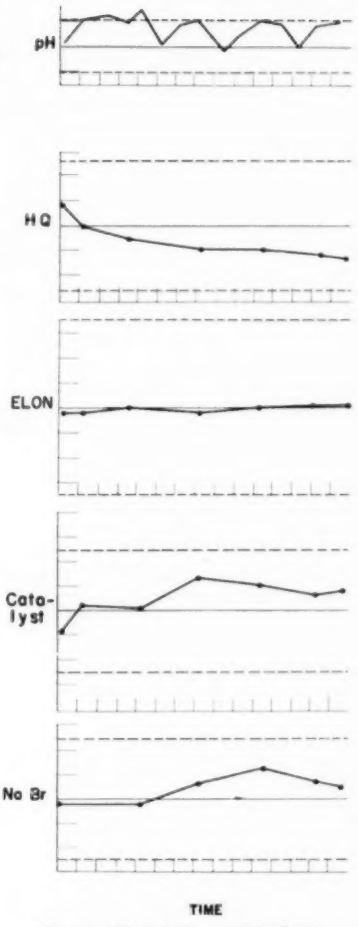

Fig. 4. Chemical control chart.

Measurements of the results will show that the images are not identical but that they differ to varying extents from some mean value about which they are clustered. The amount of variation apparent in strips processed in this manner is not at all negligible. Similarly, repeated chemical analyses of the same solutions will not be precisely alike, and again, it is futile to correct chemical levels unless the variation indicated is beyond the natural variability of the analytical method used.

As was indicated earlier, control data should be plotted on control charts in which not only a standard level, but also tolerances around the standard level are shown. These tolerances must take into account the inherent variability of the measuring tools. Indeed, in certain cases tolerances will be almost entirely dictated by this consideration. This problem is not peculiar to color processing but exists in other operations as well. Methods for handling it have been devised and a treatment of these methods will be found in the *ASTM Manual on Quality Control of Materials* published by the American Society for Testing Materials.

Conclusion

Many of the principles and methods used in the control of the Kodachrome processes will be found to apply to other processes. Some of the precautions which must be observed in the sensitometry will be found applicable to problems of printer control as well.

It should be emphasized again that a high degree of uniformity between and within Eastman Kodak Processing Stations is required not only to satisfy the needs of customers but also to insure that the films manufactured by the company will perform as the release tests indicate they should. For several years, periodic evaluations have been conducted by Eastman Kodak Co. in commercial laboratories processing its negative-positive motion-picture materials. In some of these laboratories a sufficient degree of control has been attained; in others, variations are sufficiently large so that certain batches of film have behaved in unexpected ways.

It is realized that processes in the different commercial laboratories cannot be precisely the same. Large differences between processing machines, and other factors, prevent this. However, the

present situation can be improved. Similar problems in control were encountered in the early stages of black-and-white processing, and there were repeated instances where the customer's experience with film was entirely out of line with test results. Through cooperative efforts over the years, this situation has greatly improved. If the color processes are to be truly successful, a corresponding improvement must be sought here as well.

Very little new information is contained in this discussion. It is the author's hope that it will have succeeded in emphasizing certain factors of importance in control. Of these, the following are probably of greatest importance:

(1) Present processes of color photography are chemical in nature. The photography can be controlled only by maintaining a uniform and stable chemical system.

(2) Sensitometry provides a powerful tool for process evaluation. It is, however, a tool which must be used only with meticulous attention to certain rules and details of operation. Several of these have been listed. They apply to both process and printer control.

(3) There is a certain degree of inherent variability in all tools of color-process evaluation that must be recognized, because it is significantly large. To overlook this variability in process evaluation, in printer evaluation, in comparisons between processes, or in comparisons between densitometers can lead to erroneous conclusions.

The author wishes to express the appreciation of Eastman Kodak Co. to those laboratories that are cooperating in interlaboratory comparisons. While these tests require the expenditure of additional time and effort on their part, the results will be beneficial not only to the individual laboratories but to the advancement of color photographic processes as a whole.

Discussion

Harry Lubcke (Consulting Engineer): Are color processes capable of adequate control for such work as the rush processing of color television newsreels?

Mr. Koerner: I see no reason why the commercial processor can't give uniform results whether the work is on a rush basis or on a regular service basis. Some commercial processors will perhaps be processing film on a continuous basis. Others may operate intermittently. We believe that a well controlled process can be attained in either case, although the problems encountered and the approach to these problems will be somewhat different.

Herbert Hewston (USNOTS, China Lake, Calif.): Is any difficulty encountered in freezing, thawing out and refreezing of sensitometric strips for control purposes?

Mr. Koerner: No difficulty will be encountered if certain precautions are observed. However, we try to avoid the necessity for doing this by packaging the strips in small units so that one or two days' supply can be transferred from deep freeze to a refrigerator and from there to the processing machine.

Mr. Hewston: How long a storage period for printed strips is permissible without resorting to freezing?

Mr. Koerner: The permanence of the latent image varies amongst the different photographic products. In general, we do not like to have printed strips remain unfrozen for more than a day or two. More specific information on particular films should be obtained from manufacturers' representatives.

Color-Television Film Shooting Practices

By WILLIAM B. LODGE
and HOWARD A. CHINN

The skilled professional is well acquainted with the staging, lighting, camera, film and sound recording techniques that result in successful color motion pictures for direct screen projection; however, relatively few have had the opportunity to study in detail the reproduction of film over a color-television system. Accordingly, this paper has been prepared as a tentative guide to the factors that should be taken into consideration when shooting motion-picture film for color-television applications.

IN APPROACHING the problem of making motion pictures for color television, it should be recognized from the outset that the requirements of film for television differ appreciably from those of film for theater projection. An elementary but striking example of this is the fact that for some time to come the end result will be viewed in both color and monochrome, depending upon the kind of receiver in the viewer's home. Also, as experienced television film producers have learned, television film should have a lower contrast range than theater film. For these reasons alone, if the techniques used in shooting film for the theater are followed without modification, the resulting film is not likely to be of optimum quality for television use. On the other hand, if the requirements of the television system are kept in mind, motion pictures containing all the artistry, creative expression and novel effects that may be desired can be produced.

As an aid to those responsible for the production of color film for television, this report contains tentative recommendations with regard to staging, lighting, cameras, film and sound recording. In a field developing as fast as color television, it would be unwise to present these suggestions as final. Nevertheless, they are based on considerable experience in both the film and television fields and, though further experience will doubtless produce some changes, they should be satisfactory interim guides to the filming methods of the color medium.

Some producers of television film have had considerable experience with color. Others have worked entirely with black-and-white stock. Since this handbook of recommended practices is intended to help both groups, it is hoped that the skilled professional will forgive treatment of certain subjects that, to him, are obvious.

Presented on October 19, 1954, at the Society's Convention at Los Angeles. It was read by Herbert W. Pangborn for the authors, William B. Lodge and Howard A. Chinn, Engineering Dept., CBS Television, 485 Madison Ave., New York 22.

(This paper was received October 11, 1954.)

Staging

The idiosyncrasies of current color-television equipment require that certain precautions be observed in staging practices when making color motion pictures. Further, as already indicated, staging (and lighting) practices must be designed from the viewpoint of satisfactory reproduction on both color *and* monochrome receivers. The following staging recommendations were formulated with these considerations in mind:

1. Flesh tones of a performer's shoulders, arms and back should match facial make-up. Normal variations from performer to performer are permissible.

2. Costumes and backgrounds of the same hue or luminance as flesh tones will result in loss of perspective, particularly on monochrome receivers, and the performers will not stand out from the rest of the picture.

3. In shooting successive scenes at different angles and, more particularly, at different times, great care must be taken to see that the colors of costumes, background, and make-up are identical to those photographed in earlier

takes. The chances of having glaring inconsistencies between takes is much greater when color is used.

4. Backgrounds low in color saturation, matte surfaced and of medium luminance will help avoid reflection of colored light onto other parts of the scene being photographed with consequent color contamination. In addition, it provides better contrast between foreground and background objects as seen on both color and monochrome receivers.

5. Background-to-subject reflectance ratios lower than 1 to 1½ will destroy all illusion of depth, particularly for monochrome viewers.

6. Close-ups should be emphasized and tightened about 15% as compared to practices for monochrome television in order to obtain equivalent fine detail. Even in shooting film for black-and-white television some producers have failed to keep their shots tight enough. In color the need for following this practice is even more important because of the somewhat lower resolution capabilities of the color television system.

7. Long shots, busy backgrounds and small detail, suffer even more in the color television system than they do in black-and-white. It is recommended that they be used sparingly and primarily to establish locales for special effects.

Lighting

As is well known, the hue saturation and luminance (brightness) of any surface depend not only upon the reflectance characteristics of the surface itself, but also upon the nature of the light striking the surface. Whereas in monochrome photography the color of the light has only secondary effects on gray-tone rendition, in color photography variations in the color of the illumination can seriously affect the fidelity of color reproduction.

Effective lighting is a valuable aid in preserving an illusion of three-dimensionality on a two-dimensional viewing surface. Where the final result is viewed only in color, color contrasts may be relied upon to achieve the desired result. However, in television, where monochrome viewing of color film is also involved, consideration must also be given to achieving perspective with luminance (brightness) contrasts alone. Finally, since both color-film and color-television systems can accommodate only a limited contrast range it is important that measurable factors (light levels, set and costume reflectance, film characteristics, etc.) be accurately determined and precisely maintained within the proper operating range in order to insure satisfactory and consistent results. Such latitude as is available should be relied upon to offset expected errors and variations in shooting and processing rather than to permit careless work.

1. Color temperature of all lighting sources should be checked and maintained at the specified value — usually 3200 K for color film intended for indoor shooting. Light sources should have a smooth spectral distribution (e.g., incandescent lamps and color corrected arcs).

2. Light sources of different types may be intermixed provided they have similar energy distribution spectrums and are color corrected to within 100 K of the standard value. Variations beyond the 100 K limit result in noticeable color shifts as the subject is viewed from different angles or moves from under one light source to another. Consequently, little use can be made of dimmers to control the brightness of incandescent lamps.

3. Light sources for background illumination need not be balanced so precisely provided no objects whose colors are familiar to the viewers are included in the background.

4. Ideally, key-light to fill-light ratios in the vicinity of 1½ to 1 and absolute key-light levels of at least 600 ft-c should be maintained. Larger ratios may be used sparingly to obtain desired effects, and are, of course, encountered in outdoor shooting. They are likely to result in very contrasty pictures when the film is viewed on a color-television system. Lower absolute light levels may produce too shallow a depth of focus.

5. Uniformity of lighting in the playing area is essential. Small variations in illumination can result in exaggerated deviations in the fidelity of color reproduction.

6. Flat lighting, although easy to use, results in a lack of modeling, and destroys the sense of space between objects, particularly when viewed over a monochrome television system.

7. High key-lighting results in the most consistently pure color reproduction. Low key-lighting is far less predictable in color and tends to give a muddy reproduction.

8. Subject contrast as determined by a spot-brightness meter should not exceed 20 to 1. This value is in keeping with the capabilities of the present-day color-television system.

9. Exact reproducibility of lighting, as to lighting ratios, color temperatures and direction of light, is essential to reduce to a minimum shot-to-shot and scene-to-scene variations. Accurate and reliable incident-light and spot-brightness meters are recommended, the former for setting lighting levels and the latter to control contrast. Detailed lighting plans of the entire shooting area are also recommended.

Cameras

For a given lens aperture, and assuming conventional motion-picture cameras are used, presently available color film requires approximately three times the light level that is necessary for obtaining an optimum output signal from a color-television camera. The effective speed of a color-film camera system may be said to be only one-third that of a color-television camera system and about one-tenth that of a black-and-white television camera. Identical lenses may be used for television and for 35mm film cameras. Thus, in order to obtain the same depth of focus in color motion pictures as in color-television pictures, it would be necessary to employ three times the light level used in color television. Since this would entail lighting levels in the vicinity of 1000 ft-c, it is not generally feasible to follow this procedure. Instead, lighting levels approximately twice those used in color-television work are used and the remaining difference made up by employing larger lens apertures. Consequently, the depth of focus of color motion pictures produced indoors is generally less than that obtainable from a color-television camera.

In addition, the performance of a motion-picture camera cannot be as readily checked as can that of a television camera. The television camera may be trained on a test chart and its performance determined in a few minutes by measurement and observation. The motion-picture camera, on the other hand, can only be checked by exposing test film, waiting for it to be processed and usually after a day or more the results are obtained, at which time the process may have to be repeated. This is unfortunate since, despite their relative simplicity, motion-picture cameras often develop faults that adversely affect the end result.

The camera checks outlined below are undoubtedly standard operating procedure for the professional cameraman who has worked with color film. They are, however, reiterated for the benefit of the reader who may not realize how small a latitude for error is permitted by color film. The need for carefully checking the performance of a camera and its associated lens under actual operating conditions cannot be over-emphasized.

1. Complete focusing tests should be run on all cameras and with all lenses. Since, at best, the depth of focus is limited, the distance calibration of all lenses in all cameras should be accurately known.

2. The accuracy of the range finder or visual focusing attachment, if used, should also be determined.

3. The accuracy of the viewfinder and the existence of any parallax errors should also be determined, particularly since many close-ups are likely to be involved.

4. The flatness of the field of all lenses should be checked as a function of aperture. No reliance should be placed upon a lens simply because it bears a prominent name.

5. The depth of focus of the equipment in use should be accurately ascertained. Where a follow-focus arrangement is not available, it may be necessary to raise the

lighting level and reduce the aperture until an adequate depth of focus is obtained to cover the action.

6. Any detectable jump or weave in all cameras should be eliminated. The skill and precision with which a particular camera is built and subsequently maintained largely determines the perfection of its performance; therefore, specific camera types or makes cannot be singled out as being outstanding. No reliance should be placed upon a camera simply because it was made by a well-known manufacturer.

Film

Where program material from color motion-picture film is intended to be comparable in quality to that obtainable from a color-television camera, 35mm film should be used. For broadcasting stations not equipped to handle 35mm film, reduction prints from 35mm originals should be provided. This recommendation is made because, although it is possible to make reasonably satisfactory prints from 16mm originals, in practice they are few and far between. Whereas Type 5268 Kodachrome Commercial Film is capable of producing a 16mm original that televises well, duplicates made from such originals are not of equal quality.

1. Eastman Type 5248 Color Negative Film is capable of producing 35 mm originals from which satisfactory color prints can be obtained.

2. Eastman Type 5382 Color Print Film is suitable for producing satisfactory 35mm color release prints.

3. Eastman Type 7382 Color Print Film has been successfully used for the production of 16mm reduction prints in color.

4. Exposure tests of the particular batch of film to be used in a given production should be made under actual operating conditions. This should include the lighting, the camera, the lenses and the processing laboratory that will handle the final film.

5. In critical work each job should be treated as if it were the first since changes can occur in the film because of improper storage conditions. Cameras can develop troubles and lenses can become damaged.

6. A slate containing, in addition to the usual information, a standard gray scale and color patches should be a part of every test and production shot. These slates should be carried through to the finished prints and the gray-scale steps should be large enough to permit the making of densitometer measurements.

7. The processing laboratories should be required to tag every piece of film with their own brand of sensitometer strips and these test strips should remain on the film when it is delivered. Obviously a sufficient length of unexposed film must be provided to allow the laboratories to meet this requirement.

8. Although the standards of the several acceptable processing laboratories differ from each other, continuous checks should be made to ascertain that any given laboratory is producing consistent results. In general, because of the non-existence of industry standards, direct correlation cannot be made between the data obtained from the measuring methods employed by the various laboratories.

9. A contrast range of 20 to 1 should be used as a target for the final print. This goal is recommended despite the natural tendency, resulting from direct viewing, to produce prints that, from a television viewpoint, have excessive contrast ranges.

10. The density of the highlights on finished prints should be as low as possible, consistent with retaining significant highlight detail. Glint lights and spectral reflection from jewelry, musical instruments and other highly polished objects should not be considered as "significant" highlights in determining highlight density.

11. Jump and weave introduced by poor printing machines should be guarded against by critically sampling all release prints delivered by the processing laboratory.

12. Experience indicates that considerable care must be exercised in color correcting the print released for television transmission. Although some compensation for color inaccuracies may be obtained in the television system, it must be realized that it is not feasible to make scene-to-scene adjustments during film transmission.

13. Satisfactory black-and-white prints can be obtained from color film. Until a substantial number of television stations are equipped to transmit color film, it may be desirable to utilize black-and-white prints for television transmission, even though the program has been shot on color film. Experience to date indicates that satisfactory black-and-white prints may be obtained from currently available 35mm monopack color negatives. A few producers have demonstrated that, with unusual care, acceptable black-and-white prints can be produced from 16mm Kodachrome, although it seems doubtful that this method can be generally recommended.

Sound

The soundtrack that accompanies a color motion picture is just as important as the picture portion of the print. Trite as this observation may seem, preoccupation with the picture photography has sometimes been detrimental to the sound recording operation. Since, in television broadcasting, a motion-picture presentation often follows or precedes a live production, the audience can make direct comparison of live and recorded sound. Whether this comparison is made consciously or not, the results are not likely to be favorable to film unless the track is of the highest quality. Although this direct comparison is commonplace in television, it is a test which few theater-type films have to face. The following practices, though known to technicians of the major Hollywood producers, seem to be frequently ignored by smaller producers.

1. Sound recording tests, accompanied with sensitometer strips, should be made with the equipment and the processing laboratory that will handle the final work. All subsequent work should be tagged with such test strips.

2. Minimum cross-modulation distortion, maximum signal-to-noise ratio and adequate frequency range should be the objective of the sound-recording work.

3. Violent changes in peak sound levels should be avoided. Television listeners object to the wide range of peak sound levels that apparently find acceptance in the theater.

Summary

The successful shooting of film for color television requires full appreciation of the differences between the requirements for viewing directly on a screen and for viewing on a television system. Once these differences are understood, experienced personnel should have no difficulty with the mechanics of producing color film tailored to the needs of the color-television system. The recommendations covering staging, lighting, camera, film and sound recording practices set forth in the foregoing paragraphs represent good starting points from which deviation may be made after extensive testing and field experience indicate the desirability of doing so.

Finally, one nontechnical subject warrants comment: the temptation to over-do color in the "learning" stage. Experienced color producers warn against over-emphasis of color merely for color's sake — the use of a riot of color which detracts from the play, the performers or the commercial product. There are no technical aids that can be substituted for actual experience, good judgment, artistic skill and proper organization. A reasonable share of these ingredients is required in the production of film for color-television use.

The authors gratefully acknowledge the assistance received from various members of the motion-picture and the television industries while they were undertaking the work which forms the basis of this paper. The cooperation of Karl Freund of Desilu Productions, Peter Keane of Screen Gems, Inc., Eric Howse of Technicolor Motion Picture Corp., and of Al Simon of McCadden Corp. was particularly helpful. The experimental portion of the work was undertaken under the able supervision of R. S. O'Brien and J. R. Whittaker of the CBS Television Engineering Dept., both of whom made major contributions to the undertaking.

On Photographic Exposure and Exposure Meters

By PARRY MOON and DOMINA EBERLE SPENCER

A study is made of five criteria that are being used with photoelectric instruments to determine camera exposure. The only really satisfactory method appears to be the use of maximum and minimum brightnesses for the portion of the scene range over which the photographer desires gradation. The exposure time is then found by relating these two points to the characteristic curve of the film. The poorest method seems to be the popular one of determining exposure by the average scene brightness as measured with a photoelectric exposure meter.

THE EXTENSIVE use of photoelectric exposure meters has resulted in a variety of methods for finding camera exposure. Is this variety really necessary and do the recommended methods give the same results? These questions are considered in the present paper.

The basic need in the determination of camera exposure is a knowledge of the brightness distribution in the scene. If the scene is outdoors and conditions are standard (clear day, sun at reasonable zenith angle, front-lighted subject), the photographer may utilize previous measurements or may draw on his practical experience. No new data are needed. Indeed, for scenes of this type, the brightness distribution is duplicated, day after day, with surprising uniformity; and exposure tables[1] are generally more satisfactory than meters. Even with nonstandard conditions, reasonably good results are often obtained with exposure tables.

If conditions are unusual, however, the photographer finds that exposure tables are inadequate and that the human eye constitutes an extremely poor photometer. After sunset or at night, for instance, the estimates of experts may be in error by a factor of ten or more. In many cases, guessing is prohibitively wasteful of both time and film, and some form of measurement is necessary.

The ideal measuring instrument is one that can be pointed at the scene from the camera location. It must have a very narrow field, so that the photographer can pick out important details and can measure their brightnesses without moving from his position at the camera. A visual instrument that has been used for this purpose is the Luckiesh-Taylor Helios Meter.[2] Narrow-field photoelectric instruments are also possible,[3] and one such device is now on the market.

The difficulty is, of course, that a restricted field reduces the photoelectric current and thus introduces measurement difficulties. For instance, suppose that an ordinary photoelectric exposure meter generates one microampere for a given helios (brightness), using a barrier-layer cell with shield that accepts a 60° lightcone. If now the lightcone is narrowed to one degree, the current will be reduced to approximately 1/3600 of its original value or 3×10^{-10} amps. A sensitive wall-type galvanometer would be required to measure this current. Moreover, the voltage obtained from a barrier-layer cell is so low that vacuum-tube amplification is not feasible. Another possibility is to employ a vacuum photocell with amplifier. Such an instrument can be very compact, though it cannot be produced at a price comparable with that of the present wide-field exposure meters using barrier-layer cells.

If the photographer is limited to the commercially available photoelectric exposure meters, his only recourse in measuring scene details is to place the meter very close to the detail so that all light from other objects is excluded from the cell.[4] Such a compromise is not ideal. For glossy surfaces, the readings obtained in this way may differ considerably from the brightness as seen from the camera. Also, the photographer must be careful not to cast a shadow or to allow his white shirt to reflect additional light onto the scene.

The average amateur is probably satisfied if 50% of his pictures are acceptably exposed. To achieve such a level of performance, he needs only the crudest methods. The present paper is not addressed to him: it is addressed to those of us who employ photography as a scientific tool. We may not need it very often; but when we do need it, the subject will probably be a difficult one, lighted in an unorthodox manner. Moreover, we cannot be satisfied with 50% failures: we need 100% satisfactory results.

It is believed that the photographer can obtain this ideal if he is willing to make the necessary photometric measurements and to use a satisfactory method of calculation. A comparison of schemes for calculating exposure will be given in this paper. Following modern scientific practice, we shall express all quantities in mks (meter-kilogram-second) units. The mks unit of photographic "exposure" (lumen sec m^{-2}) is employed universally, and it is only reasonable to express other quantities in the same system.[5]

A contribution submitted on May 26, 1954, by Parry Moon, Massachusetts Institute of Technology, Cambridge 39, Mass., and Domina Eberle Spencer, University of Connecticut, Storrs, Conn.

Necessary Data

To obtain consistently good results with unusual subjects, the photographer should have data on

(a) the scene, (b) the lens, (c) the film.

The ratio of maximum to minimum scene brightness has been investigated a number of times, and various average values have been given,[6] ranging from 5.5 to 160. In another paper,[7] we have tried to show that the *overall* scene ratio is meaningless, since the photographer is ordinarily interested in securing gradation over only a somewhat limited range. The necessary and sufficient data needed for the scene are the *upper and lower brightness limits of the region in which detail is desired.*[7] This information is not obtained automatically: it is the result of measurement, *plus a conscious act in deciding what parts of the scene are to be emphasized and what parts neglected.*

The lens enters into the calculation of camera exposure as regards transmittance and vignetting.[8] We need an equation relating the measured brightness of the scene and the incident light on the film. For ordinary conditions, this relation is[9]

$$D_Q = \frac{\tau \zeta H_P}{4f^2} \qquad (1)$$

where

- H_P = helios (brightness) at a given point P of the scene. The mks unit (blondel) is equivalent to one lumen m^{-2} reflected from a perfectly diffusing surface[5]
- D_Q = lumen m^{-2} incident on the film at a point Q corresponding to the object point P
- f = relative aperture of lens (f-number)
- $\tau(\Theta)$ = transmittance of the lens at angle Θ from the axis
- $\zeta(\Theta)$ = factor which includes vignetting and $\cos^4 \Theta$.

The best way of evaluating $\tau(\Theta)$ for a given lens is by measurement; but a calculation is sufficiently accurate for many purposes. Table I gives approximate transmittances on the axis, neglecting absorption in the glass and assuming a transmittance of 0.960 for each uncoated surface and 0.985 for each coated surface. With a Tessar, for instance, n=3 and the transmittance is 0.91 for a coated lens. Most $f/1.5$ (Leica Summarit and Summarex, for instance)

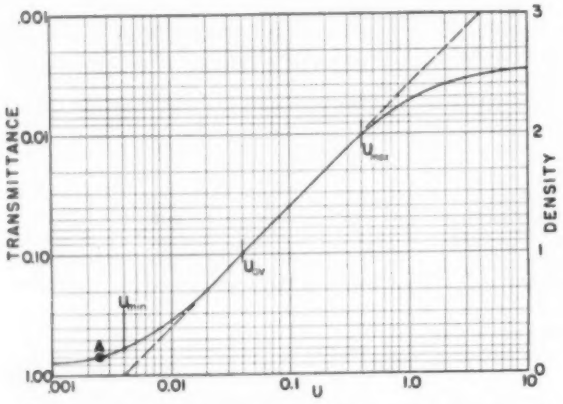

Fig. 1. Characteristic curve for a high-speed panchromatic film developed to $\gamma = 1.00$. The ordinates represent transmittance of developed negative; the abscissae represent lumen sec m^{-2} incident on the film. Slope of curve at point *A* is 0.3 of the average slope over a range of 1.5 log units, so ASA exposure index of this film is 1/0.0025 = 0400 or ASA rating is 100.

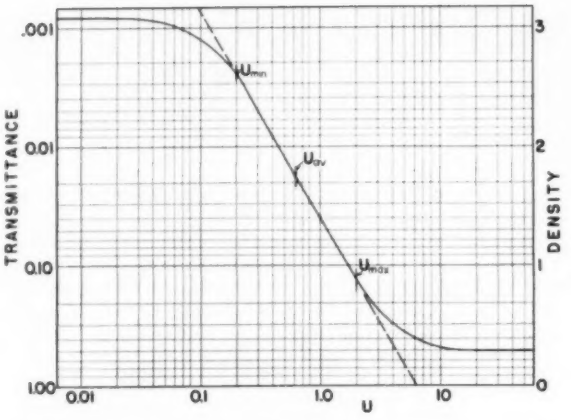

Fig. 2. Characteristic curve for a color transparency. Ordinates represent transmittance of the transparency, abscissae represent lumen sec m^{-2} incident on the film. U_{min}, U_{av}, and U_{max} are arbitrary limits used in determining camera exposure.

Table I. Approximate Transmittance of Lenses. (n = number of distinct elements separated by air spaces, 2n = number of glass-air surfaces.)

n	Transmittance, $\tau(0)$	
	Uncoated	Coated
1	0.92	0.97
2	0.85	0.94
3	0.78	0.91
4	0.72	0.89
5	0.67	0.86

lenses have n=5, with $\tau(0) = 0.86$ for a coated lens.

At points off the axis, the lumen m^{-2} is reduced according to $\cos^4\theta$ and also by vignetting produced by the lens barrel or other obstructions. For an average coated lens, at 15° from the axis, we may take the axial transmittance as 0.90, $\cos^4\theta = 0.871$, vignetting as 0.85, giving $4/\tau\zeta = 6.0$. This value will be assumed in the remainder of the paper. Thus Eq. (1) may be written in the simple form

$$t/f^2 = \frac{4U}{\tau\zeta H_P} = \frac{6U}{H_P}, \qquad (2)$$

where

$U = Dt$ = lumen sec m^{-2} incident on film
t = effective exposure time (sec).

The characteristic curve of the film is also needed. Figure 1 gives typical data for a high-speed panchromatic emulsion (Weston rating 100). The straight portion covers a ratio of approximately 100:1. Jones[10] has shown that the toe of the curve is also useful, down to point A, where the slope of the curve is 0.3 of the average slope over a range of 1.5 log units. Point A fixes the American Standard Exposure Index of a negative material:

$$\text{ASA Exposure Index} = 1/U_A.$$

Other negative films have characteristics whose shape is very much like Fig. 1. Data may be obtained from the manufacturers[11]; or Fig. 1 may be used as an approximation by merely shifting the horizontal scale in accordance with the film ratings (ASA or Weston). Figure 2 gives a curve for a color transparency obtained by reversal. Its Weston rating is 8. Note that the straight part of the characteristic covers a range of only 10:1.

Having measured the helios at point P of the scene, we can use our judgment in locating this point on the characteristic curve. Decide on a value of U: then Eq. (2) determines the *camera exposure*[12] t/f^2. Any combination of t and f^2 having the proper ratio will, of course, be allowable provided it gives sufficient depth of field and sufficiently small t to stop movement.

Exposure Criteria

Now consider the various criteria that are advocated for determining camera exposure:

(1) range of subject,
(2) darkest object,
(3) brightest object,
(4) integrated effect,
(5) incident light.

In (1) — the fundamental method — the photographer decides on H_{max} and H_{min}, the upper and lower limits of the region over which he wants gradation. He then locates these two points in favorable positions on the characteristic curve (Fig. 1). A double exercise of judgment is required: first in deciding what parts of the scene are truly important, secondly in deciding where on the characteristic to place the selected region. If the ordinary negative-positive process is employed, there is often a considerable range of camera exposure that will allow excellent prints.[10] If the negative is reversed to form a transparency, however, the latitude of exposure is greatly reduced.

The common idea of a single unique camera exposure for a given scene is untenable: there is no such thing as "THE correct exposure." Exposure depends on what the photographer wishes to emphasize and what particular effect he expects to produce. This is obviously true in art photography, but it is true also in scientific work.

In attempting to reduce this vagueness in camera exposure, Jones[10] has advocated that exposure times be based on the darkest detail in the scene, Criterion (2). The darkest object is always located at a fixed point on the toe of the curve (Fig. 1), which says in effect that THE correct exposure = *minimum* exposure that will give gradations in the darkest part of the scene. The advantage is that the photographer is freed from making a decision as to the placement of H_{max} and H_{min} on the characteristic, and thus the amateur can be a true robot. Disadvantages are the difficulty of finding and measuring the blackest part of the scene. Also, the toe of the curve is greatly affected by scattered light in the camera. An elaborate method has been developed for evaluating[10] this scattered light; but the effect depends not only on the lens and camera but also on the brightness distribution in the scene. Criterion (2) tells us nothing about what happens to the highlights, and the method is not applicable to Kodachrome or other reversal processes.

With the third criterion, only the brightest detail in the scene need be measured. The advantage is that the brightest part of the subject is often quite definite and easily measured. But obviously (3) gives no information about what will happen in the shadows.

The most popular scheme seems to be (4). The exposure meter is held with the barrier-layer cell facing the scene.

In some designs the exposure meter is even built into the camera. Because of the wide acceptance angle of the cell, the reading of the microammeter gives a sort of average brightness of the scene. There is a specious plausibility to the argument that the reading of the instrument under these conditions must be closely related to THE correct exposure. The trouble is again that we are trying to act the robot and to sidestep the necessary decision as to where gradation is important and where it is not. If we are interested in gradation in the clouds over a distant landscape, the method may overexpose; if we are interested in a portrait in the shade, sky light around the edge of the scene will probably cause the meter to read high, with consequent underexposure of the face. Jones and Condit[6] in a study of 126 outdoor scenes found that Criterion (4) gave widely variable results. Berg[13] took Kodachrome photographs of a large number of typical outdoor scenes, basing exposure on an exposure table and on a Weston meter. The exposure table gave much more consistent results.

A method that has gained some popularity recently is (5). The light falling on the subject is measured instead of the reflected light. The scheme is inherently wrong, since the camera operates on light reflected toward it, not on the light that is incident on the scene. Thus (4) always requires the additional assessment of *reflectance* ρ, and Eq. (2) becomes

$$t/f^2 = \frac{6U}{\rho_F D_F} \qquad (3)$$

where D_F represents the lumen m^{-2} incident on the scene at P.

Criterion (4) therefore introduces an additional unknown (ρ), which is not particularly easy to measure or to guess. For example, a medium brown suit might be estimated at $\rho = 0.20$; but actual measurement[14] shows $\rho = 0.04$. A carpet might be assessed at 0.15, but measurement[15] gives 0.015. The result is an error of 5:1 or 10:1 in exposure time, which is too serious to be tolerated.

Examples

The study may be made more definite by applying the various criteria to a few specific examples. These are hypothetical scenes, though the data are based on rather extensive measurements and calculations. Outdoor scenes have been chosen principally because they are more easily visualized than scientific applications. The same general procedure and conclusions, however, apply also to the latter. The criteria have been applied in a rather mechanical way, as would be done by a person with little photographic experience. The results obtained in this way are undoubtedly worse than those obtained by an expert photographer, who unconsciously draws upon a wealth of previous experience.

Table II. Hypothetical Scenes.

	Detail	H (blondel)	Meters H_{av}	Meters D
I.	*Distant Landscape*, Direct sunlight with some cloud shadows, front lighting, 2 P.M.			
	Important range 17.5:1 — Clouds max	35000	14000	57000
	Important range 17.5:1 — Clouds min	16000		
	Important range 17.5:1 — Blue sky	15000		
	Important range 17.5:1 — Distant hills	9000		
	Important range 17.5:1 — Wheat fields, in sun	12000		
	Important range 17.5:1 — Wheat fields, in cloud shadow	3000		
	Important range 17.5:1 — Grass, in sun	8000		
	Important range 17.5:1 — Grass, in shadow	2000		
	Important range 17.5:1 — River	4000		
	Important range 17.5:1 — Foliage max	5000		
	Important range 17.5:1 — Foliage min	1500		
	Important range 17.5:1 — Tree trunks	800		
	Important range 17.5:1 — Shadows under trees	200		
II.	*A white house* in direct sunlight. Clear day, front lighting, 3 P.M., near view.			
	Blue sky	13000	31500	70000
	House max	50000	Important range 8.3:1	
	House shadows	6000	Important range 8.3:1	
	Grass	8000		
	Bushes	1500		
	Shadows under bushes	100		
	Open window	20		
III.	*Same as II* but with a figure standing in front of house. Face shaded by large hat. Close view.			
	Face max	1130	—	31500 70000
	Face avg	650		
	Face min	375		
IV.	*Harbor scene.* Clear sky, front lighting, 7 P.M.			
	Blue sky	12000	7500	47000
	Fishing boat sun	3500	Important range 17.5:1	
	Fishing boat shade	200	Important range 17.5:1	
	Water	4000		
	Wharf max	2000		
	Wharf min	20		
	Distant yacht	20000		
	Reflection in water	15000		
V.	*Winter scene.* Clear sky, side lighting, 11 A.M.			
	Sky	10500	21000	9700
	Snow sunlit	34000	Important range 3.7:1	
	Snow shadow	9300	Important range 3.7:1	
	Water in brook	2800		
	Tree trunk max	1500		
	Tree trunk min	760		
VI.	*Autumn scene.* Dark clouds, diffused light, 4 P.M.			
	Clouds max	4100	2000	1700
	Clouds min	1500	Important range 5.8:1	
	Ground	710	Important range 5.8:1	
	Tree trunks	40		
	Distant cloaked figure	25		
VII.	*Outdoor portrait.* (Girl in white dress.) Slight haze, back lighting, 2 P.M.			
	Sky	21000	19500	11000
	Hair sun	26000		
	Hair shadow	1900		
	Face max	12000	Important range 12:1	
	Face min	1000	Important range 12:1	
	Shoulder in sun	83000		
	Dress in shadow	4000		
VIII.	*Living room.* Artificial lighting using daylight fluorescent lamps (cove system + floor lamp).			
	Lamp shade max	12000	600	100
	Lamp shade min	1500		
	White ceiling max	4100		
	White ceiling min	520		
	Wall	11		
	Piano highlight	480		
	Piano avg	8	Important range 4:1	
	Table top	30	Important range 4:1	
	Chair	12		
	Shadows under furniture	0.1		

Data for eight scenes are listed in Table II. Brightness values (in mks units) are given over the complete range of the scene, even though a photographer would ordinarily disregard part of this range.[7] The integrated values (H_{av}) are also listed, as well as values of lumen m^{-2} (D) incident on a vertical surface facing the camera.

Exposure time is first calculated for Kodachrome, assuming the curve of Fig. 2. The limits for correct rendition are taken, more or less arbitrarily, as 0.2 and 2.0 lumen sec m^{-2}, with a geometric mean of 0.63 lumen sec m^{-2}. For Scene I, the important part of the brightness range is from the clouds at 35000 to the grass at 2000 blondels.

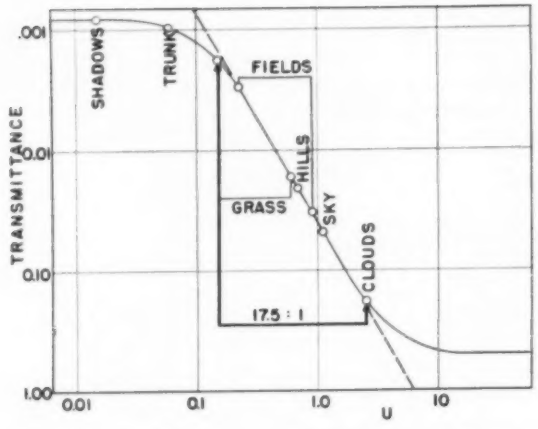

Fig. 3. Location of the elements of Scene I on the curve of Fig. 2 when $t/f^2 = 4.5 \times 10^{-4}$. The important part of the scene covers a range of 17.5:1, and this range is located as nearly as possible on the straight part of the characteristic.

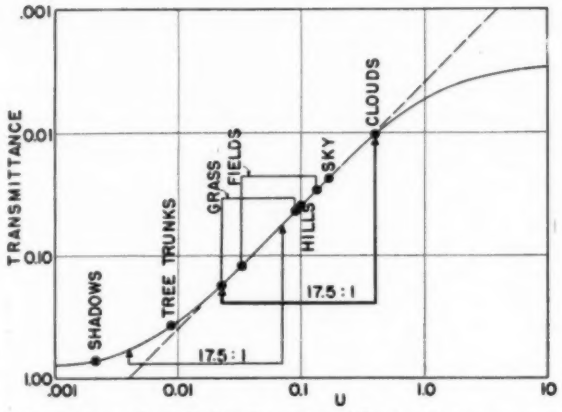

Fig. 4. Scene I applied to the curve of Fig. 1 with $t/f^2 = 6.9 \times 10^{-6}$ (0.018 sec at $f/16$). The points are arranged so that the clouds correspond to $U_{max} = 0.40$ near the upper end of the straight part of the characteristic. Any other exposure is allowable, down to approximately 0.003 sec at $f/16$, which corresponds to the lower of the 17.5:1 brackets.

Darker objects need not be rendered correctly. Placing this range symmetrically on the characteristic curve, we obtain the conditions shown in Fig. 3.

The geometric mean of 35000 and 2000 is 8370, which we place at $U_{av} = 0.63$. Then, according to Eq. (2),

$$t/f^2 = \frac{6U_{av}}{H_P} = \frac{6(0.63)}{8370} = 4.52 \times 10^{-4}.$$

At $f = 5.6$, the exposure time is

$$t = 0.014 \text{ sec}$$

or approximately 1/60 sec according to Criterion (1). For Criterion (2), we place the darkest detail (200 blondels) at $U_{min} = 0.2$. Thus,

$$t = 6(0.2)(5.6)^2/200 = 0.19 \text{ sec at } f = 5.6.$$

For Criterion (3), let $H_{max} = 35000$ correspond to $U_{max} = 2.0$, or

$$t = 6(2.0)(5.6)^2/35000 = 0.011 \text{ sec.}$$

For (4), place $H_{av} = 14000$ at $U_{av} = 0.63$. Then

$$t = 6(0.63)(5.6)^2/14000 = 0.008 \text{ sec.}$$

For (5), assuming a reflectance of 0.1, we obtain

$$\rho D = 0.1(57000) = 5700, \text{ so}$$

$$t = 6(0.63)(5.6)^2/5700 = 0.021 \text{ sec.}$$

Exposure times for the other scenes are calculated in a similar manner and are listed in Table III. The values marked "meter" were obtained from the circular slide rule of a well-known type of photoelectric meter with Criterion (4), while the values marked "guide" were obtained from the *Daylight Exposure Computer*[1] of Eastman Kodak Co. The exposure times in boldface type are considered satisfactory. For Kodachrome, any value differing by a factor of more than 1.5 from the value obtained by Criterion (1) is considered underexposed or overexposed and is enclosed in parentheses.

Table III. Calculated Exposure Time for Kodachrome. (Exposure times in parentheses are considered unsatisfactory.)

$U_{min} = 0.20$, $U_{av} = 0.63$, $U_{max} = 2.0$ lumen m^{-2}

Scene	I	II	III	IV	V	VI	VII	VIII
Important range								
H_{min}	2000	6000	375	200	9300	710	1000	8
H_{max}	35000	50000	1130	3500	34000	4100	12000	30
For (1)								
H	8370	50000	650	3500	34000	1710	3470	16
U	0.63	2.0	0.63	2.0	2.0	0.63	0.63	0.63
Total range								
H_{min}	200	20	20	20	760	25	1000	0.1
H_{max}	35000	50000	50000	20000	34000	4100	83000	12000
H_{meter}	14000	31500	31500	7500	21000	2000	19500	600
ρ (assumed)	0.10	0.80	0.80	0.30	0.80	0.10	0.30	0.50
H (from D)	5700	56000	56000	14100	7750	170	3300	50
f	5.6	5.6	3.2	4	8	2	4	11
Exposure time, sec / *Method* / *% satisf. exposures*								
(1) 100	**0.014**	**0.008**	**0.060**	**0.055**	**0.023**	**0.009**	**0.017**	**2.9**
(2) 13	(0.19)	(1.9)	(0.61)	(0.96)	(0.10)	(0.19)	0.019	(1450)
(3) 50	0.011	0.008	(0.002)	(0.010)	0.023	0.012	(0.002)	(0.12)
(4) 13	(0.008)	(0.004)	(0.001)	(0.008)	(0.012)	0.008	(0.003)	(0.76)
(5) 38	0.021	(0.002)	(0.007)	(0.004)	0.031	(0.089)	0.018	(9.11)
Meter 13	(0.004)	(0.003)	(0.0009)	(0.007)	(0.010)	0.007	(0.003)	(0.67)
Guide 57	0.01	0.01	0.04	(0.01)	0.02	(0.02)	(0.04)	—

Table IV. Calculated Exposure Time, for panchromatic film, Fig. 1, with 4× filter. (Exposure times in parentheses are considered unsatisfactory.)

$U_{min} = 0.004$, $U_{av} = 0.040$, $U_{max} = 0.400$ lumen sec m^{-2}

Scene	I	II	III	IV	V	VI	VII	VIII
Important range								
H_{min}	2000	6000	375	200	9300	710	1000	8
H_{max}	35000	50000	1130	3500	34000	4100	12000	30
f	8	8	5.6	5.6	32	5.6	8	16
Exposure time, sec / *Method* / *% satisf. exposures*								
$(1)_{min}$ 100	**0.003**	**0.001**	**0.008**	**0.015**	**0.011**	**0.004**	**0.006**	**3.1**
$(1)_{max}$ 100	**0.018**	**0.012**	**0.27**	**0.086**	**0.29**	**0.073**	**0.051**	**82.**
(2) 38	(0.031)	(0.31)	0.15	(0.15)	0.13	(0.12)	0.006	(246.)
(3) 75	0.018	0.012	(0.006)	0.015	0.29	0.073	0.007	(0.20)
(4) 63	0.004	0.002	0.001	(0.004)	0.047	0.015	(0.003)	(0.41)
(5) 50	0.011	0.001	(0.0005)	(0.002)	0.13	(0.18)	0.019	**4.9**
Meter 50	0.005	0.002	(0.002)	(0.005)	0.07	0.016	(0.002)	(0.40)
Guide 57	0.01	0.01	0.01	(0.01)	0.16	(0.12)	(0.10)	—

Note that the values calculated by Criterion (1) are generally in good agreement with those obtained from exposure tables or guides. But the other methods of calculating exposure are very uncertain, (4) being one of the worst offenders. This agrees with the work of Berg[13] and with the qualitative experience of most photographers.

A similar analysis is made for high-speed panchromatic film, Table IV and Fig. 4. Here the camera exposure is much less critical than for Kodachrome. Even here, however, best results are believed to be obtained with Criterion (1). Exposures are considered unsatisfactory if they lie outside the range found for Criterion (1).

Conclusions

The conclusions of this study are as follows:

(A) An ideal exposure meter should have a very narrow field so that scene details can be measured from the camera position. Scattered light within the instrument should be negligible, and the response curve should be adjustable to various photographic materials so that different film ratings for daylight and incandescent light are unncessary. The instrument may be either visual or photoelectric, though the latter is easier to operate.

(B) Of the five methods of using photoelectric exposure meters, the only one that gives consistently good results for all subjects and all methods of lighting is No. 1: the adjustment of maximum and minimum brightnesses to the characteristic curve of the film.

(C) The other methods are attempts to simplify camera exposure so that the photographer can dispense with judgment and thought. The results are highly uneven — sometimes good, more often bad.

(D) The usual way of estimating exposure by use of average brightness measured by the ordinary photoelectric meter (Criterion 4) generally gives poor results.

(E) Exposure tables give surprisingly good results for outdoor scenes and standard conditions. The exposure times are generally better than those obtained by Criterion 4.

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The Photometric Range of Outdoor Scenes

By PARRY MOON and DOMINA EBERLE SPENCER

A number of researches have been made to determine the photometric range of outdoor scenes. The results are considered of importance in the determination of photographic exposure and as criteria for the improvement of artificial lighting. The data obtained by different investigators differ so widely, however, that one becomes suspicious. An examination indicates that the concept of overall range is meaningless and should be abandoned.

THEORETICAL investigations of photographic exposure usually introduce the *photometric range* of the scene — the ratio of maximum to minimum brightness. For an average subject, Hurter and Driffield[1] (1890) found a ratio of 30; Mees (1913) gave a value of 20; Goldberg[2] (1922) gave 30; while an extensive investigation by Jones and Condit[3] (1944) showed an average ratio of 160, with minimum 27 and maximum 760 for a group of 126 scenes. On the other hand, a somewhat similar investigation (also in New York State) by Logan[4] in 1939 resulted in ratios of 2.4 to 35. Additional measurements[5] in Mexico (1944) gave similar results. Unpublished work done at M.I.T. in 1949 led to ratios from 3 to 12.

Since most of the recent measurements were made with the same type of photometer,[6] in which scattered light is not very troublesome, this disturbing factor is not responsible for the discrepancies. In any case, the small effect of scattered light within the instrument could not account for the large differences found by various investigators. How, then, can one scientist claim a ratio of 5.5 for average outdoor scenes while another claims 160? The thesis of this paper is that *the concept is meaningless philosophically and worthless practically.*

A contribution submitted on September 23, 1954, by Parry Moon, Massachusetts Institute of Technology, Cambridge, Mass., and Domina Eberle Spencer, University of Connecticut, Storrs, Conn.

Experimental Data

The first of the modern investigations was published in 1939 by Logan.[4] Twenty-five photographs were taken of typical outdoor scenes, and the distribution in each scene was measured with a Luckiesh-Taylor instrument. The data were obtained over a period of five months and the conditions included snow, rain, overcast sky and clear weather. The purpose of the investigation was not to obtain photographs but to find characteristics of nature which might be applied to the improvement of artificial lighting for rooms. Nevertheless, those who selected the scenes apparently exercised a certain amount of aesthetic judgment. The work was continued in 1943–4 so that in all there were 89 scenes investigated.[5]

Table I. Natural Scenes (New York State).

Logan				Jones and Condit			
No.	H_{max} (blondel)	H_{min} (blondel)	H_{max}/H_{min}	No.	H_{max} (blondel)	H_{min} (blondel)	H_{max}/H_{min}
1	3000	380	7.9	7	22600	130	174
2	5900	400	14.8	6	38700	99	390
3	8600	1400	6.1	18	21500	65	330
4	25000	1800	13.9	27	31700	190	167
5	17200	1100	15.6	31	43000	88	490
6	34000	3900	8.7	32	12900	88	146
7	35000	3700	9.5	34	24200	62	390
8	22400	3400	6.6	39	22000	150	146
9	14500	1700	8.5	45	19400	150	130
10	43000	1400	30.7	60	34400	140	236
11	47000	2000	23.5	72	37600	125	300
12	30000	2000	15.0	73	83000	240	346
13	20000	2800	7.1	75	34400	160	215
14	34500	960	36.0	76	19300	130	148
15	25000	850	29.5	77	34400	60	573
16	14600	6000	2.4	78	42000	170	247
17	12400	4300	2.9	79	20400	150	136
18	1880	120	15.6	80	15000	330	46
19	12800	370	34.6	81	11800	90	131
20	21500	1000	21.5	83	17200	240	72
21	7800	380	20.5	86	21500	130	165
22	60000	4300	14.0	88	12900	190	68
23	19500	5300	3.7	89	17200	130	132
24	21500	2600	8.3	90	6670	160	42
(Geometric mean)			(11.6)				(380)

Table II. Some Additional Data (Cambridge, Mass.). Distant or Semidistant Scenes, Front-Lighted, Clear Day, Luckiesh-Taylor Helios Meter.

Scene No.	Object	Helios (blondel)	H_{max}	H_{min}	H_{max}/H_{min}
1	Sky (clear)	12000			
9 A.M.	Yellow brick building	13500	13500		
D.S.T.	Grass	6000			
	Macadam pavement	4500		4500	3.0
2	Sky (clear)	14000			
10 A.M.	Granite building	15000	15000		
	Shadows	3500			
	Deep shadows	2500		2500	6.0
	Grass	8000			
	Trees	4500			
3	Sky (clear)	14000			
10 A.M.	Granite building	17000	17000		
	Shadows	3500		3500	4.8
	Bushes	6500			
	Grass	10000			
5	Sky (clear)	17000			
2 P.M.	Building (max)	21000	21000		
	Building (avg)	16800			
	Building (shadow)	1800		1800	11.7
	Pavement	7000			
	Sidewalk	12000			
6	Sky (slight haze)	20800			
2 P.M.	Yellow brick building	21800	21800		
	Distant hills	15000			
	Black roof	9100			
	Grass	7000			
	Macadam pavement	6500		6500	3.4
7	Sky (clear)	16000			
1:30 P.M.	Buildings: 19000, 9000, 12000		19000		
	Trees	5000			
	Water	4000		4000	4.7
9	Sky (very clear)	12000	12000		
7 P.M.	Buildings: 12000, 4000				
	Trees	2000		2000	6.0
	Water	6000			
16	Sky (clear)	1400	1400		
after	Distant building	420			
sunset	Distant trees	160			
	Water	700			
	Boat in foreground	140		140	10.0
19	Sky (a few cumulus clouds)	18000			
3 P.M.	Cloud	30000			
	Water	9000		9000	4.5
	Sailboat	40000	40000		
20	Sky (clear)	16000			
4 P.M.	Cloud	35000	35000		
	Bridge	8000			
	Distant buildings	9000			
	Grass	8000			
	Water	6000		6000	5.8
(Geometric mean)					(5.5)

Data[4] for the first 24 are listed in Table I. These scenes may be classed as distant or semidistant.

The other extensive investigation was made by Jones and Condit.[8] The data were obtained over a period of 18 months and the scenes included a wide variety of subjects. In most cases, however, the sky was clear and the subject was front-lighted. One might expect that this uniformity in lighting would result in lower ratios than those obtained by Logan with his wide variety of weather conditions and camera orientations. The opposite is found, however, as can be seen from Table I. The geometric mean of Logan's results is 11.6, while the geometric mean of the 24 scenes of Jones and Condit listed in Table I is 380.

A word of explanation is needed regarding Table I. The two sets of data were originally given in different photometric units. It seemed advisable to express them in the same unit,[7] preferably the *mks* (*meter-kilogram-second*) *unit** rather than some hybrid. This is particularly true since the universally accepted unit of photographic "exposure" is the mks unit (lumen sec m^{-2} or "meter-candle-second"). The Jones and Condit scenes of Table I are the first 24 of their Group 3: "near-by, sunlit, front-lighted, unshaded." The fact that the Logan scenes are more distant than the 24 Jones and Condit scenes would tend to reduce the Logan ratios, though it could not be responsible for the great discrepancy shown in the table. The mean of all the Jones and Condit results is 160, the mean of their most distant scenes is 81, which is still far above the 11.6 of Logan.

A few additional data are given in Table II. Here the purpose was somewhat different from either of the previous investigations. Our idea was to photograph only those scenes which offered particularly pleasing gradation, entirely free from glare. The ratios obtained from such scenes should provide a useful criterion for ideal room lighting. Since no statistical analysis was desired, the work was limited to one month (May) and to one location (Cambridge, Mass.). Furthermore, no attempt was made to measure the darkest detail in the field: small dark areas were disregarded as being unimportant both aesthetically and photographically. As might be expected, the average ratios obtained with these criteria are somewhat lower than Logan's average, though we did not reach his lowest value of 2.4.

The Upper Limit

The ratio depends on both upper and lower limits of scene helios (bright-

* One *blondel* is equivalent to one lumen per square meter reflected from a perfectly diffusing surface. One millilambert = 10.0 blondels, 1 "ft-lambert" = 10.76 blondels.

ness). Consider first the maximum helios[7] in the scene. Nearly all the experimental results have been obtained on clear days with the sun back of the camera, a condition that generally gives low helios ratios. With an overcast sky, the zenith sky[8] is necessarily the brightest thing to be seen, and even white objects will appear dark in comparison. On clear days, however, an asphalt pavement or a grass plot in direct sunlight may not appear much darker than the sky, while a white surface will be brighter than the sky.

Consider, for instance, an open landscape in direct sunlight. The blue sky constitutes the brightest part of the scene, with distant hills, fields, grass and trees forming a descending scale. Suppose that the helios ratio is 50. Now introduce a small white object such as a distant billboard or a house on the hill. This object, being in direct sunlight, may have a helios five times that of the sky. Thus the helios ratio of the scene has suddenly jumped from 50 to 250. Yet exactly the same camera exposure should be used in the two cases. The two pictures should be identical except for a small white spot in the second print. This spot has a definite shape, which can be distinguished both in the original scene and in the print, but gradation in the white object is of no importance, and overexposure of this part of the negative has no possible significance.

Even more startling changes in the scene ratio may be caused by specular reflection — from waves in the lake, from automobiles, from bits of metal or glass. Such trivia may raise the scene ratio to 10^9, yet they have no bearing on camera exposure. Evidently the photometric range or scene ratio is an illusive quantity which may be given almost any value, depending on unimportant details in the scene which have nothing to do with exposure.

The Lower Limit

The above conclusion is even more obvious when we consider the darkest part of the scene. In most landscapes, there is a rather wide range of gradation at the lower end of the brightness scale: sunlit foliage, foliage in shade, tree trunks, shadows under trees, etc. In going down this scale, where does one stop?

As an example, consider a near view of a white house in sunlight. Data, based on measurements, are given in Table III. In deciding on the scene ratio, should one concentrate on the important question of gradation over the house wall (8:1 ratio) or should one consider the bushes (33:1 ratio), or the shadows under the bushes (500:1 ratio)? Taking the scene ratio literally, however, one should certainly consider as minimum brightness the interior of the rooms as seen through the open windows. This gives a ratio of 2500:1. True, these openings appear black from the outside; but they have a definite brightness which can be measured.

Table III. A Scene.

Detail	Helios (blondel)
House { max	50000
House { shadows	6000
Sky	13000
Grass	8000
Shadows under porch roof	5000
Bushes { avg	1500
Bushes { shadows beneath bushes	100
Open windows	20

This example again indicates the indefiniteness of the scene ratio. Photographically, the important part of the scene of Table III is the range from 50,000 to 6000 blondels. There would be no advantage in showing detail in the rooms or in the shadows under the bushes.

The vagueness of "minimum brightness" is particularly troublesome if one accepts the postulate that camera exposure *must* be based on this quantity.[9] In the scene of Table III, for instance, a camera exposure that places either the windows or the bush shadows at the approved point on the toe of the characteristic would give a hopelessly overexposed negative.

Exposure

The indefiniteness of the scene ratio seems to have bothered Jones and Condit, for in 1949 they said[9] "differences which are invisible to the normal observer need not be reproduced in order to achieve an excellent positive. All that are visible should be reproduced." In other words, the scene ratio should not be the ratio of the brightest to the darkest details, as measured by a perfect physical photometer, but should be limited to those areas in which a normal observer can see detail.

But this is also an unsatisfactory criterion. Photography cannot be standardized to this extent. In trying to produce a work of art, the photographer is continually frustrated by the wealth of trivial detail which the camera persists in including and which ruins the unity of the picture. If deliberate overexposure leads to a more artistic result, it should be used. At the other extreme, we have the scientist who is using photography as a tool. He also does not want a photograph that reproduces exactly what he sees: he wants, if possible, a photograph that shows a great deal *more* than he sees. Between these two extremes are all sorts of other photographic ideals, but in very few cases do we wish to produce all and no more than the normal observer sees.

These remarks should not be construed as criticism of Jones' outstanding work, which undoubtedly constitutes one of the real milestones in photographic progress. The series of papers[5,9] by Jones and Condit develops a simplified procedure suited to the needs of the average amateur.[10] If 100,000 amateur photographers can raise their percentage of passable negatives from 50 to 70%, that is something!

But for the professional photographer or for those who need photography occasionally as a scientific implement, such a statistical average is not good enough. We cannot afford to have less than 100% of our negatives satisfactory. Such an ideal is obtainable only if we know the characteristic curve for the film, data for the camera and lens, and data for the scene.[11] Necessary and sufficient data for the scene are the upper and lower helios limits *for the region in which we want detail.* Rarely will either of these limits coincide with H_{max} or H_{min} of the scene. There is no shortcut by which the camera exposure can be determined automatically on a statistical basis.

It is evident, therefore, that the concept of *scene range* is untenable. An exact definition involves almost insuperable difficulties, and its practical importance in either illuminating engineering or photography is essentially nil.

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Use of Photography in Ballistic Measurements

By GEORGE E. MERRITT

This is a survey of the photographic methods and apparatus used to obtain detailed pictures of missiles in flight and of shockwaves and other phenomena of the medium through which such missiles pass, and to determine space-time coordinates of ballistic events. Special emphasis is placed on apparatus developed and used at the U.S. Naval Proving Ground.

THE USUAL PURPOSE of photography is to reproduce something that the photographer sees in order that others may see it also. The principal purpose of ballistic photography is to record events which nobody has ever seen, and which nobody *can* see, except in the pictures. Even in those cases, for example rocket flight, where the event is visible, even spectacular, the eye is so subject to optical illusions that observers may get a very distorted idea of what actually occurred. In ballistic photography at the Naval Proving Ground we set up our cameras, focus them on a calculated position in space where there is no object (and where no object will ever be visible to the eye), calculate the time when that point in space will be occupied, arrange some automatic means to have the shutter open at that time, and then retire to a shelter and hope for the best.

The events follow each other with such rapidity that almost all camera operations must be automatic. In some cases it is even impossible to use ordinary electrical relays, and electronic devices must be utilized.

Various measurements of time are also of the highest importance, and hence all the pictures must include timing marks. Most of the time intervals involved must be measured in thousandths, or even millionths of a second.

These three conditions, invisibility, rapidity and the importance of time relations, lend a unique flavor to ballistic photography.

There are four classes of ballistic information which can be obtained by photography:

(1) space-time coordinates;
(2) aspect of the missile;
(3) detailed pictures of the missile in flight; and
(4) shockwaves, and other phenomena of the medium.

Space-time coordinates include four dimensions, the three ordinary quantities by which any position in space is determined, plus the time at which the object occupied that point. The absolute time is not important, but the time in relation to some other event, for example, the time of fire, must be found as accurately as possible.

Space-time coordinates are obtained for two general classes of problems. The first is the determination of trajectories.

For bombs, which are usually large and comparatively slow moving, the cinetheodolite is the preferred instrument. The cinetheodolite is essentially a motion-picture camera, mounted (in place of a telescope) on a theodolite. Its advantage is that the target does not have to be exactly on the cross wires when the observation is taken, hence very rapid observations on moving targets are possible. The scale readings, recorded at the same time as the picture, indicate the line of sight of the center of the reticle. Position of the image on the frame provides a correction from which the actual direction of the target from the theodolite position can be calculated. Time is determined by synchronizing the pictures or by putting time marks on the film. Sighting telescopes are collimated with the camera so that the operators can follow the target. Simultaneous observations of two or more instruments are used to triangulate the observed phenomenon.

At the Naval Proving Ground, the cinetheodolites are synchronized by radio from a central synchronizing station, and a radio signal from the airplane starts the picture taking a few seconds before the bomb is released. The first pictures are of the airplane and the operators cannot see the bomb as a separate target until some time after it is actually released. Therefore, the time of release of the bomb is sent by radio from the airplane and is recorded along with data from the cinetheodolites on a chronograph at the central control station. The path of the bomb is tracked by the operators as near to impact as possible. The terminal position is usually photographed by means of a Mitchell Chronograph camera, which is a motion-picture camera with a picture of a synchronized time recorder impressed in the corner of each frame.

The positions of all cameras must be accurately known with respect to the impact point.

In the case of gun-launched missiles (ordinary projectiles) which are usually too fast as well as too small to be tracked by the operators, the usual method is to define the trajectory by setting the projectiles to explode at different times. This provides a number of discrete points through which an average curve can be drawn. At the Naval Proving Ground we usually determine each point from an average of several bursts. The cinetheodolites are pointed at the expected burst position and the flash or smokepuff is recorded. The space-time coordinates of the initial point are determined by nonphotographic means. The terminal point is determined with the Mitchell Chronograph camera.

Cinetheodolites are also sometimes used on the trajectories of rockets and on the earlier parts of the trajectories of guided missiles.

Another instrument used on some types of trajectory determination is the ballistic camera. These are fixed cameras equipped with large plates, 8 × 10 in. or larger. Multiple exposures of a moving object are made on the same plate. The position and orientation of each camera is established by careful survey and the relation of these positions to the launching site is known.

These cameras are calibrated by taking pictures of the stars and comparing the results with star charts. Measurements on the plates of positions of the image and the known base line between the two cameras are used to triangulate the position of the object.

The simplest reduction of observations is obtained by setting the focal planes of the two cameras in the same plane. The data can, however, be reduced from other orientations. When the lines of sight of the cameras are nearly enough horizontal to include part of the ground, known points in the landscape can be used as check points to see that the lines of sight are parallel. In order to limit exposure, a screen with a long narrow slot is moved manually across the field.

A time scale is introduced either by having the airplane or other target carry a light which flashes at regular intervals, or by a shutter which makes exposures at a certain frequency. Great care must be taken to insure that the shutters of both cameras are synchronous. The electronic means designed at the Naval Proving Ground to accomplish this fills a whole van.

A very useful instrument for use on the larger targets is the Exterior Ballistic Radar (EBR). This is a cinetheodolite with an instrumental-type, automatic-tracking radar with the radar beam

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parallel to the camera's line of sight. Figure 1 shows the EBR. This instrument was converted from an SCR-584 at the Naval Proving Ground. The van houses the radar equipment and circuits for synchronizing all the cameras. The EBR can be used as a self-tracking cinetheodolite and has the additional advantage that the radar gives the distance to the target at all times. This makes it possible to obtain the position of the target with one, instead of two instruments. As long as the target can be recorded by the cameras, this instrument has an angular accuracy of 0.2′; and after the image becomes too small to see, the radar can still give an accuracy of about 6.0′ of arc. The instrument can also keep track of a target that passes behind a cloud and will continue to take pictures after it emerges. Besides the field camera, which is collimated with the radar beam, there is a camera that takes a picture of the azimuth and elevation scales, and one that photographs the range scope. These three cameras are synchronized, so that pictures on all three are simultaneous. Common time and event markers are also recorded on the edges of the film, which makes the reduction of observations easier.

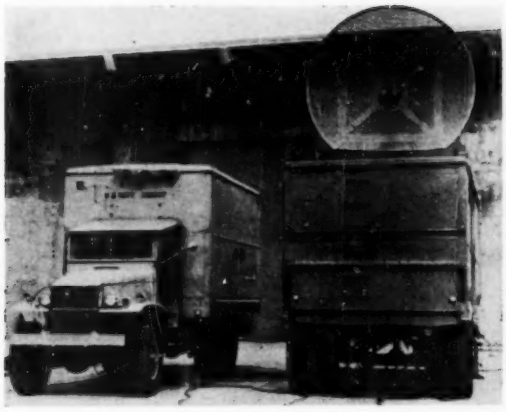

Fig. 1. Exterior view of Exterior Ballistic Radar.

Space-time coordinates may also be used for obtaining the relationship between two *closely related* events, such as:

(1) emergence of projectile from gun as related to time of fire;

(2) relation of impact to fuze action;

(3) burnout of rockets as related to ejection from launcher; and

(4) emergence of rockets from launcher with ignition time.

The determination of accelerations and decelerations also involves the same kind of measurements.

Fastax, Eastman High Speed, Bowen, smear cameras and some special cameras are used for this kind of work. For some things, for example, rocket burnout, a Mitchell Chronograph camera can be used, and a specially developed camera has been used to take pictures of projectiles just emerging from the gun muzzle, but most of this work is done with the Fastax and Bowen.

The smear camera does not take a regular picture at all. In this device the image is "smeared" across the film in a direction at right angles to the significant motions of the objects to be photographed. For example, suppose a continuously moving film moved at right angles to the trajectory. In such a picture a passing projectile would be represented by a diagonal band crossing the film. The angle between the edge of the band and the direction of the film would be a measure of the speed of the projectile as compared with the speed of the film. In many cameras of this type the film is stationary and the optical image is smeared onto the film by means of a revolving mirror. This method is capable of producing very high relative speeds of film and image, but has the disadvantage that the action is discontinuous.

This brings up a problem which is ever present in ballistic photography, the question of "common time." Although most of our cameras at the Naval Proving Ground have provisions for putting 1000-cycle time markers on the edge of the film, so that the relation of any two events photographed on the same film can be related in time, this is not enough. We must also have some means of relating this data to other films, other events, some not directly photographable, such as the initiation of fire, the emergence of the projectile from the muzzle, the time an airplane crosses a certain coordinate, etc. Sometimes the cameras are started, a certain amount of film is run off without timing marks, and then the timing marks on all the films are started simultaneously. In some cases a special fiducial mark is put on the film, similar to the timing mark, but distinguishable from it. In other cases it is necessary to get the camera running and to trigger the detonation from some part of the camera action. This last must be done with rotating-mirror smear cameras.

As an instance of the sort of problems which come up in this field, a set-up at the Naval Proving Ground involving a Mitchell Chronograph camera may be described in some detail. In this case, we had to photograph two events on the same film, so that the indications of the little clock which appears in the corner of each frame would be continuous. Equipment for synchronizing clocks was not available and the position where the camera had to be placed made it impossible to include both events in the same field of view. The events were about 4 sec apart, and at different distances.

We covered this assignment in this way. We removed the detents from the lens turret and put a lever on it with special stops so that either of two lenses could be in register. In front of one lens we mounted an adjustable prism. Then we sighted the second lens on the expected position of the second event, turned to the first lens, and, without moving the camera, adjusted the prism so that the first event would be in the field. The two lenses were focused on their respective distances. The camera was started, brought up to speed, and the first event was recorded; the lever was flipped, bringing the second lens into register, and the second event was recorded. The film and clock were running all the time.

Aspect of the Missile

Let us now consider, briefly, the aspect of the missile. This refers to the angle which the axis of the missile makes with its trajectory. In this case we do not need a very good picture of the missile; a silhouette, not too much blurred, is sufficient. In the case of the large, high-altitude missiles, such as they deal with at White Sands, pictures of the aspect of the missile at very high altitudes are important. There, such pictures are obtained by means of very long focus, telescopic-type, tracking cameras. The focal lengths used are from 150 to 350 in., and the weight of the camera and mount is given in tons. For bombs, the pictures taken with the Askania cinetheodolites for the purpose of determining the shape of the trajectory are usually sufficient to show the aspect also. In some cases, a smaller tracking camera with a lens of only 96-in. focal length is used. Pictures taken from the airplane with specially constructed cameras may also be used to determine the fluctuations in the initial part of the path.

In the case of gun-launched, spin-stabilized missiles, the yaw is usually greater near the muzzle. In this case, observations on the aspect can be made from close to the trajectory. At the Naval Proving Ground twelve Fastax cameras, set along the trajectory with overlapping fields are sometimes used to cover the first 400 ft of travel. Of course, if complete yaw in both planes is to be measured, these pictures must be supplemented by others taken from directly under the trajectory.

Besides the Fastax pictures taken

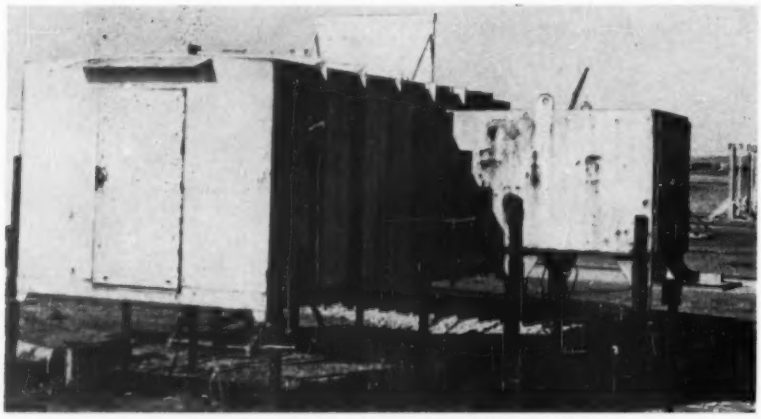

Fig. 2. The microflash dark box.

normal to the trajectory, we sometimes take pictures along the trajectory, looking either "downstream," or "upstream." A Fastax camera is placed behind heavy armor plate beneath the trajectory about 400 ft in front of the gun and pointed "downstream" at a high angle into a mirror. This mirror is set on a stand nearly or exactly on the trajectory and the camera is started by a sequence timer on the firing bridge. The result is a very good picture of the projectile coming straight at the observer. The mirror is expendable.

Detailed Pictures of Missiles in Flight

A very important phase of ballistic instrumentation is the taking of *detailed pictures of missiles in flight*. These pictures are taken to determine the condition of the missile at some time after it is launched and before it arrives at its destination. They may be taken before and after the missile has had certain adventures, such as passing through a deflection plate, or before and after shedding sabots or other separable members.

For slow-moving missiles (less than 2000 ft/sec) the Bowen camera can be used for this kind of work. For the majority of small projectiles, which can be conveniently and safely passed through a darkroom, the microflash technique is preferred.

In order to free the microflash equipment from the laboratory, the Naval Proving Ground has constructed several portable, armored, dark boxes which can be set up in the field in front of any gun position, as shown in Fig. 2. These are cross-shaped structures consisting of a long tunnel for the entrance and exit of the projectile with a cross section of about 5 × 5 ft. Near the middle of this tunnel are two rooms, one on each side, which are about 8 ft high, 8 ft wide and 12 ft along the dimension at right angles to the tunnel. These are for the accommodation of the cameras and other microflash equipment. The tunnels, both "up" and "down" stream, are closed by several cardboard partitions so that before the projectile gets there the interior is entirely dark. The camera shutters can therefore be opened by remote control well in advance of the arrival of the projectile. After the last cardboard partition in the entrance tunnel is punctured by the projectile, a small amount of indirect light is admitted, but, since the time is short before shutter closing, this is not enough to fog the negative. Just before the projectile gets to the camera room it passes through a beam of light about ¼ in. thick which is viewed by an electric eye. This puts a signal into an electronic delay circuit which flashes the microflash lamp when the projectile gets right in front of it.

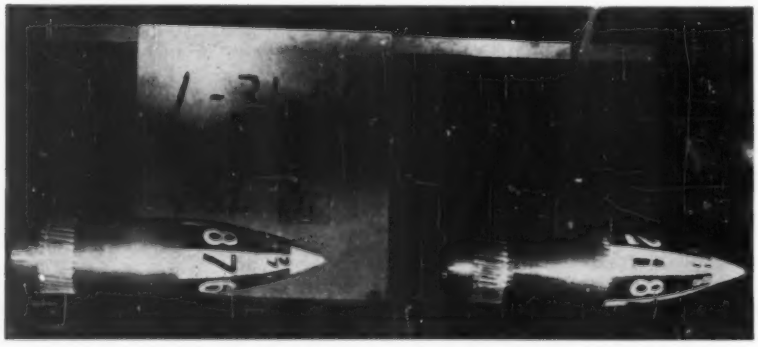

Fig. 4. A microflash double exposure of a spinning projectile.

Figure 3 is an example of the high quality of picture obtainable by this technique. Microflash pictures are noted for their excellent detail. This projectile was moving at 2,500 ft/sec.

Sometimes another electronic delay circuit, triggered by the first, counts off a certain number of millionths of a second and then flashes another light pointed at a spot on the trajectory about 4 ft farther along, thus taking another picture of the same projectile on the same or another film, as shown in Fig. 4. The last flash actuates a shutter-closing mechanism so that the shutter is closed as soon as the picture is taken. Usually, 4 × 5-in. still cameras with 5-in. lenses, or 8 × 10-in. still cameras with 10- or 12-in. lenses are used. Sometimes two cameras are placed one above the other and pointed in a parallel direction. This gives a stereo pair. Sometimes oblique pictures are taken showing the nose or base of the projectile. The particular setup is governed by the kind of information desired. Projectiles as large as 8-in. caliber have been successfully photographed while passing through these dark boxes.

Fig. 3. A typical microflash photograph of a spinning projectile having a velocity of 2500 ft/sec.

In case spin is to be measured, the projectile has to be painted in alternating segments of black and white and the bands numbered as shown in Fig. 4. We can then measure the amount that the projectile has turned between the time the first picture was taken and the time the second one was taken. Since this time has been counted off to a high accuracy by an electronic counter, the spin can be obtained immediately in rpm.

A special camera has been developed at the Naval Proving Ground for taking pictures of this kind outside the darkroom. This camera, known locally as the Ballistic Synchro, is an instrument of the strip-camera type, with a constantly moving film and a stationary slit placed crosswise to the film motion. The camera and its control equipment are shown in Fig. 5. In this view the camera is set up for a shot from directly beneath the trajectory. The armor plate is for protection from blast, since the camera is only 70 ft from the gun. The principle on which it works is that of matching the velocity of the *image* of the missile continuously with that of the film. This synchronization of the two velocities eliminates the translational movement

of the image with respect to the film. If no other motion is present, a point of the image remains at the same point on the film during the time the image is crossing the slit.

Since the camera and slit are stationary, the whole picture is taken in the same plane in space and events passing through that plane are recorded in the temporal order of their occurrence. The width of the picture is a regular space dimension, but the length of the picture is a time dimension. As a result, pictures are not limited in length by the angular field of the lens.

Figure 6 is a picture taken with the Ballistic Synchrocamera. This was a spinning projectile moving at 2600 ft/sec. In comparing this with the microflash picture it should be noted that the rifling marks shown correctly in the microflash picture as at a slight angle to the projectile axis are, in this picture, shown as parallel with the axis.

In cases where the projectile has disintegrated before passing through the camera field, we still get a record of the

Fig. 6. A typical Ballistic Synchro picture of a spinning projectile. Compare with Fig. 3.

event (Fig. 7). Needless to say such an event as this would be extremely unwelcome in a microflash darkroom.

Ballistic-Synchro pictures are used in fuze study, rotating band study, assessment of damage to projectiles from passing through a thin plate, separation studies (where a projectile normally sheds parts during flight), and fragmentation studies as well as spin rate and velocity.

Disturbances of the Medium

Besides the pictures of the projectile itself, it is sometimes of interest to obtain pictures showing the reactions of the medium through which the shell is passing. Ever since the spherical cannon ball was superseded by a cylindrical body with a cone-shaped ogive, the streamlining of the missile has been receiving increasing attention. For such studies the shockwaves and other disturbances of the medium must be studied.

The oldest method used to obtain such information is the "spark picture" (Fig. 8). This is a "shadowgraph" or lens-less method. A small bright spark is set off on one side of a projectile as it passes a point where the shadow thrown by the spark will fall on a sensitive surface. Inequalities in the density of the air will cause some of the light from the spark to

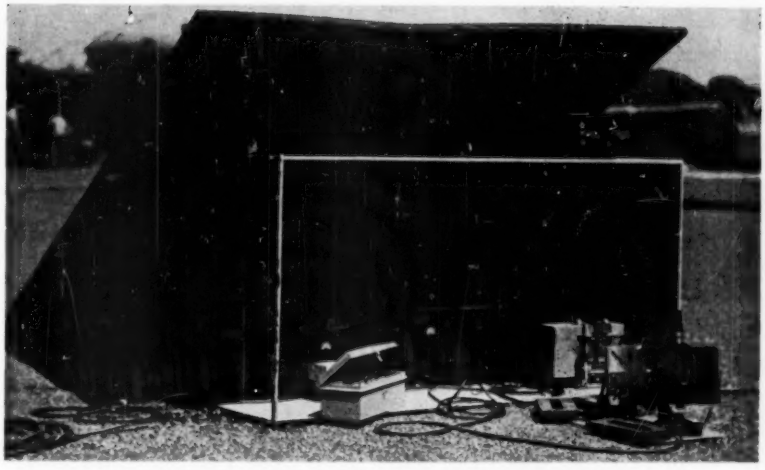

Fig. 5. A typical field installation of the Ballistic Synchrocamera. Control and auxiliary equipment are in the background.

be refracted, causing shadows on the negative. The microflash dark boxes described above are equipped for this use. The flash, a smaller and shorter one than that used for taking the detailed microflash pictures, is placed and fired as before. On the wall back of the missile trajectory is mounted a large negative. After the flash, an automatic shutter covers the whole negative to protect it from further exposure. The chamber behind the negative is then entered, darkened, and a door is let down which allows the plate to be removed from its mount and placed in a light-tight box for later development.

The Schlieren setup (Fig. 9) yields pictures which superficially resemble the spark pictures, but in this case the fact that the source of light is a uniformly illuminated geometrical figure (cross section shown), the light from which is uniformly distributed over the field, results in an image which is more amenable to mathematical analysis.

The Ballistic Interferometer (Fig. 10) is arranged so that the undisturbed field results in a certain fringe pattern, and disturbances in the field result in a change in pattern of the fringes. Measurements of the amount of this change, expressed in fringe widths, may be used to obtain the actual change in refractive index, and hence the change in density or pressure of a localized part of the field. These three methods require special darkrooms through which the projectile passes.

In outside field work it is sometimes desired to get a picture which will give the information of the spark shadowgraph. This can be done by introducing into the background a regular alternation of intensities, such as an array of dark wires against a sky, or a black-and-white striped board. The greater density of the air in the regions of compression bends the light so that it appears to be coming from a part of the background having a different optical intensity. This is known as the "broken wire effect."

The velocity of a shockwave is of the order of the speed of sound, which is too fast for the eye to appreciate. Shockwaves are therefore not only invisible to the eye, but will not be seen in any picture except those taken with very short exposures, 1/10,000 sec or less.

At the Naval Proving Ground there is a great and increasing interest in the use of photography for obtaining ballistic

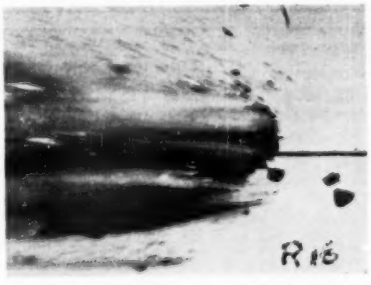

Fig. 7. A picture of a missile disintegrating in flight. This was obtained by the Ballistic Synchrocamera.

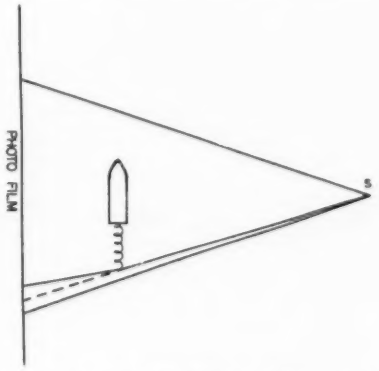

Fig. 8. Layout for spark photography.

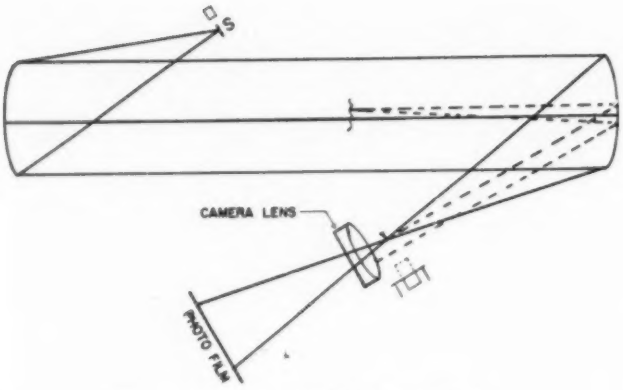

Fig. 9. Layout for Schlieren photography.

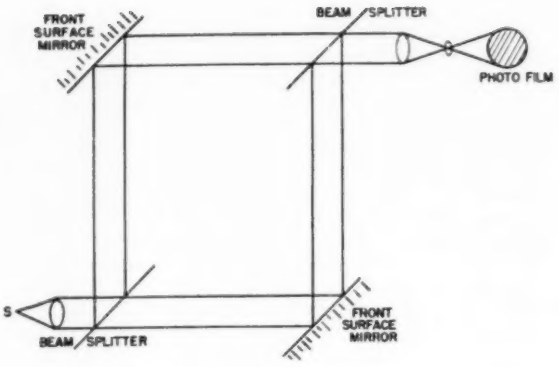

Fig. 10. The Ballistic Interferometer.

information. For the information given in this paper I have drawn heavily on my experiences there, but any opinions expressed are my own and should not be taken as the official views of the Naval Proving Ground.

Discussion

D. R. White (General Electric Research Laboratory): Have you used your ballistic synchrocamera in conjunction with an interferometer?

Mr. Merritt: No. We have never had occasion to do that.

Mr. White: I thought it would be an interesting experiment to try.

Mr. Merritt: The synchrocamera records only things that are moving in a definite direction at a certain speed. Interferometric patterns are usually static, or nearly so.

Mr. White: Could you, for example, take a picture of a projectile passing through an interference field? Wouldn't you get your pattern?

Mr. Merritt: Yes, it would give you a good picture of the projectile going down its trajectory. You would get a complete record and also a record of the movement of the interference fringes. We haven't done that, but it would be possible.

News and Reports

The 76th Convention

The general feeling at the end of the recent get-together in Los Angeles was that the convention had been particularly successful. Registration did not reach the phenomenal numbers of the last Los Angeles convention, chiefly because this time there were fewer spectacular demonstrations of new techniques that drew so much public interest on that occasion, but attendance was large by any normal standards. Active participation and interest ran high; both individuals and participating companies seemed to be going all out to make the meetings and social functions as useful and enjoyable as they could.

Total registration for the week was 770, including 78 ladies. The Get-Together Luncheon drew 320, and the Banquet 440, both figures being well above the usual proportion for attendance at these functions. Numbers attending sessions stayed well up to normal or better, and the high spots, such as the VistaVision demonstration at Paramount and Ralph Evans' color paper, drew large crowds.

The Program

The accent was on color, and particularly on color television. The first two days' sessions were devoted entirely to descriptions of equipment, film applications and techniques for color television, including theater television in color. Both NBC and CBS gave demonstrations of their systems, and one session included an interesting tour of the facilities of CBS Television City. Aspects of educational and military uses of television were covered in another session.

Color film sensitometry also drew a good deal of interest. One of the highlights of the week was the paper by Ralph M. Evans on "Color and Brightness in Projected Color Pictures," which was given in the Academy Award Theatre in order to take care of the large attendance.

Other parts of the program covered magnetic recording and reproduction, high-speed photography, motion-picture equipment and cinematography. The high point in attendance and general interest was the demonstration of VistaVision given at the Paramount Studios by Loren Ryder. This was handled in two sessions, in order to accommodate the crowds, and run concurrently with a demonstration by John Frayne of a two-channel photographic stereophonic sound system.

Get-Together Luncheon

With more than 300 on hand, the convention got an excellent start at the luncheon in the Cocoanut Grove of the Ambassador. Herbert Barnett, the Society's outgoing president, welcomed members and guests with the following address:

"We met last in Los Angeles eighteen months ago. Our memory of West Coast hospitality is still fresh and that perhaps accounts for the very fine out-of-town attendance at this convention.

"In any event, from my advance look behind the scenes the past two days, I can assure you that extensive preparations have been made by our local members and by the management of this beautiful hotel to make your stay here both pleasant and profitable.

"A year and a half ago the motion-picture industry was entering one of its most interesting and exciting periods. Every one of us had been in some way affected by the widespread talk of disaster which arose from a declining box office and from reports of theater closings. We had become aware that a new interest in motion pictures was essential to the survival of our industry.

"What transpired since is well known to each of you. Today our industry is enjoying the fruits of a two-year investment in engineering and applied research.

"It is a rare and welcome occasion indeed that permits the motion-picture engineer to contribute directly to the immediate benefit of his industry. Through his ability to meet these responsibilities, he has gained greater esteem and prestige, and has moved forward into a new position of prominence.

"The accomplishments for which engineering gets the credit have been called miracles by a generous motion-picture trade press. Because engineers are of a practical turn of mind, we prefer to think of wide screen pictures and stereophonic sound as the result of many thousands of man-hours of just plain hard work.

"But in a very real sense, these accomplishments are the result of new and effective teamwork between

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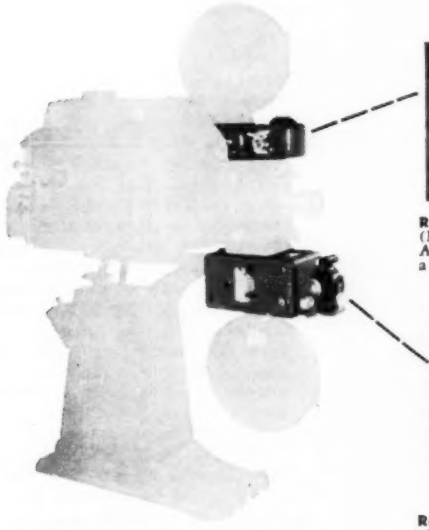

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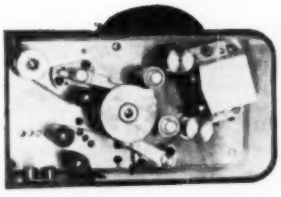

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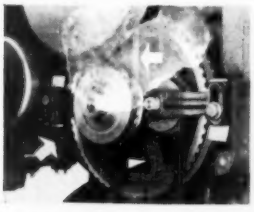

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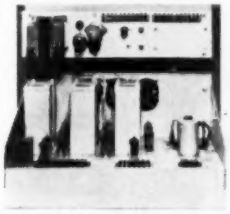

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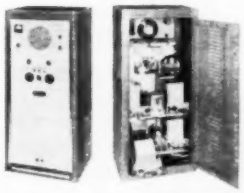

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"That guidepost directs our attention to some of the very things to be discussed at this 76th Convention of the SMPTE.

"Important as the past months have been, we must recognize that we cannot relax our efforts nor assume that the job is done. Technical achievements were a major factor in revitalizing motion-picture business. Technical advances must lead the way to still greater heights.

"The technical revolution which started with the success of wide-screen pictures is still underway, and further developments now in progress, with a resulting enhancement of theater presentation. Our industry can no longer stand pat for extended periods. It must be dynamic. Its creative minds, both artistic and technical, must continually key themselves to the changing tastes and attitudes of its paying audience.

"There is no surer way to do this than through continuation and strengthening of the teamwork attitude which has marked recent progress. Engineering must continue to meet the challenge in keeping alive this harmonious working relationship. Management will, I am sure, recognize and sponsor the increasing stature of its engineers.

"In television there is equal opportunity for participation in the development and progress of an important communication medium. Born of a different era than the motion-picture engineers, there is evidence that the television engineer has achieved greater success in this direction. There is, however, need for constant diligence on his part to contribute still further to steady growth and prosperity in his highly specialized field.

"There is of course the every increasing need for closer integration of motion pictures and television. This affords an excellent opportunity for engineers working together to assume leadership in promoting the way to this goal.

"This great organization of motion-picture and television engineers can continue to play a vital role through its technical sessions, committee work, standardization and — most important of all — as a key source of information through its *Journal* and other publications."

President Herbert Barnett with Award Winners (l to r) Ray D. Kell, Lorin D. Grignon and Armin J. Hill.

Following the President's address, the luncheon gathering relaxed for a while with the Society's guest of honor, actor Pat O'Brien, who contributed to the general geniality with a succession of good tales, excellently told.

President Barnett announced the results of the election of officers (the new slate was reported in the November *Journal*, p. 198), and before going on to present the Society's annual awards, announced that two special awards were being given this year.

Awards

The first was to *Arthur C. Downes*, who for nearly fourteen years has been Chairman of the Society's Board of Editors. The Board of Governors, meeting a few days before, had unanimously made this special award in formal and grateful recognition of the long years of patient and painstaking effort Mr. Downes has devoted to maintaining the high quality of the articles published in the *Journal*. Mr. Downes has been ill, and the Society sent him every good wish for a quick recovery.

A special achievement award was also presented in absentia jointly to *Earl I. Sponable* and *Herbert E. Bragg*, Twentieth Century-Fox Film Corp., in recognition of their contributions to the development of anamorphic photography and projection which, as CinemaScope, "exerted an influence of major importance on the motion-picture industry." A telegram of acceptance from the recipients ran: "We are happy to receive your notice of the SMPTE special award for Cinema-

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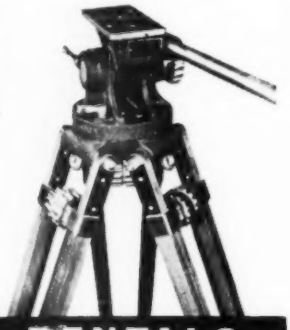

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Scope development. The rapid success of this undertaking and its wide acceptance by the motion-picture industry is the result of the fine cooperation and assistance given by all our friends, particularly in the Society, and by other motion-picture engineers everywhere in the world. We are grateful to all and especially to Spyros Skouras and the other executives of Twentieth Century-Fox who were willing to stake the future of the company on engineering know-how and back it to the limit. The future of motion pictures now looks very bright and with the improvements on the horizon the health and prosperity of this greatest of all media of mass entertainment seems assured. We are sorry to be unable to be present but want to extend our best wishes for a successful convention and regard to all."

The SMPTE Journal Award, for the most outstanding technical paper originally published in the Society's *Journal* during 1953, was presented to:

Armin J. Hill for "A Mathematical and Experimental Foundation for Stereoscopic Photography."

Honorable Mention for outstanding papers was given to:

A. V. Loughren for "Recommendations of the National Television System Committee for a Color Television Signal,"

F. Dana Miller for "Rapid Drying of Normally Processed Black-and-White Motion-Picture Film,"

Otto H. Schade for "Image Gradation, Graininess and Sharpness in Television and Motion-Picture Systems — Part III: The Grain Structure of Television Images,"

Edward Schmidt and *Ernest W. Franck* for "Manufacture of Magnetic Recording Materials" and

William B. Snow for "Basic Principles of Stereophonic Sound."

A special mention was given to:

John A. Norling for "The Stereoscopic Art — A Reprint."

Ray D. Kell, research scientist at the Radio Corp. of America Laboratories Div., was awarded the David Sarnoff Gold Medal Award for outstanding achievements in the development of television and important contributions to color television. The citation recorded that Mr. Kell received the award:

". . . for his many pioneering achievements in television beginning with his pioneering work in mechanical scanners in 1926, through epoch-making developments in all-electronic black-and-white television and most recently in color television, a career covering more than a quarter century.

"For his prominent role in adapting the compatible all-electronic color television signal to the prescribed limitations of a 6-megacycle channel.

"For the impetus given by him to the development of numerous television system apparatus, including the first iconoscope tube camera and cameras for both monochrome and color utilizing the image orthicon.

"For his untiring work as a member of Main Panel 13 of the National Television Systems Committee and as chairman of two subcommittees, labors which contributed notably to the formulation of the NTSC color television signal specifications accepted by the industry and adopted by the Federal Communications Commission in December 1953."

Lorin D. Grignon, Twentieth Century-Fox Film Corp., was presented the Samuel L. Warner Memorial Award for his engineering work in stereophonic sound now widely used in wide-screen film presentations. This citation ran:

"As though in preparation for CinemaScope, the Sound Department at Twentieth Century-Fox undertook the development of systems and techniques for application of stereophonic sound to motion pictures ten years ago, in 1944, 1945 and 1946. This development work was under the supervision of Lorin Grignon, whose background in the communications field and years of experience in the motion-picture sound recording activity placed him in an excellent position to carry on this work. It was therefore natural that when the cyclone of CinemaScope struck the industry he should be assigned to play an important role in the commercial development of the medium. His was the responsibility for the engineering and coordination of many phases of CinemaScope — particularly the application of stereophonic sound, standardization of the release film, application of magnetic sound recording for release prints, supervision of magnetic striping and printing equipment, and preparation of engineering

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data for release throughout the world. The Samuel L. Warner Memorial Award is presented to Mr. Lorin D. Grignon, recognizing that the outstanding success of stereophonic sound with CinemaScope pictures, both in this country and abroad, is in a large measure due to the engineering skill, good judgment and hard work which he contributed in such generous measure to this activity."

The Banquet

Quite apart from the record attendance, this event started off on a successful note with the cocktail party held outdoors beside the Ambassador Pool. There the guests enjoyed an Aquacade display which was added to the program through the generosity of General Film Laboratories. At the dinner and dance that followed, Miss Connie Haines was the star performer. Here most helpful contributions were made by Byron (Byron, Inc.) Roudabush, who provided wine for the entire company, and Sid Solow (Consolidated Film Industries), who took care of two hours of overtime on the part of the orchestra.

New Fellows

The one official act of the evening was the conferring of Fellowships on sixteen of the Society's members. The new Fellows are:

Philip G. Caldwell	Everett Miller
John R. Clark, Jr.	Harry F. Olson
Albert A. Duryea	Richard H. Ranger
Ralph H. Heacock	Reid H. Ray
Armin J. Hill	Hazard E. Reeves
Lester Isaac	Ralph A. Teare
U. B. Iwerks	R. Edward Warn
George Lewin	James L. Wassell

a message of interest to:

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ALL film should be treated, if you are to get maximum results in terms of good projection and number of showings. Without treatment, your film—from initial release to the last booking—is much more susceptible to damage. And damaged film can result in an indifferent audience.

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And, if you have film that has become "hurt" or "tired"—scratched, edge-nicked, brittle, warped, or just dirty and oily, call on Peerless service to salvage it—not only your prints, but also your negatives and originals.

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Equipment Exhibit

Announcement that an equipment exhibit would be run at this convention attracted such interest that by the time the convention actually opened all available space had been stretched to the limit and no less than 28 exhibitors had been accommodated. Throughout the week this concentration of the latest in equipment was a focus of attention and activity, drawing quite a few local visitors in addition to convention registrants. Response in general was so good that serious consideration is being given to making such exhibits a permanent convention feature. The exhibitors were:

Arcturus Engineering Co.
Army-Navy
Bell & Howell Co.
Traid Corp.
Berndt-Bach, Inc.
Cameraflex Corp.
Encyclopedia Britannica, Inc.
Frank Herrnfeld Engineering Corp.
General Precision Laboratory Inc.
Gordon Enterprises
Hollywood Film Co.
Houston Fearless Corp.
Kling Photo Corp.
Koessler Sales Co.
Metropolitan Electric Mfg. Co.
Mole-Richardson Co.
Moviola Mfg. Co.
Otto K. Olesen Co.
Photo Research Corp.
Photo Sound Products Mfg. Co.
Prestoseal Mfg. Co.
Producers Sales Corp.
Radiant Mfg. Co.
Radio Corp. of America
Resultant Engineering
S.O.S. Cinema Supply Corp.
Westrex Corp.
Wollensak Optical Co.

Arrangements

The success of this convention is a matter for which all those listed below deserve the Society's warmest congratulations and thanks. A tremendous amount of work went into the careful planning and execution of the multifarious details, from the putting together of the program itself down to the placing of tables and chairs for the registration and information desks. The thoroughness of the job done by the local members showed up in the smooth and successful operation of the whole.

Program — Ralph E. Lovell
Papers — W. H. Rivers, J. E. Aiken, S. W. Athey, C. E. Heppberger, G. G. Graham, J. H. Waddell
High-Speed Photography — Carlos H. Elmer
Exhibits — Thomas J. Gibbons, Jr., Allan C. Curtis
Local Arrangements — Philip G. Caldwell
Registration and Information — Robert P. Young, Arthur Johnson, Herman Herles, Donald Prideaux, Peter Vlahos, Howard Bell, William Farley
Hotel Reservations and Transportation — Betty Hartlane, Vaughn C. Shaner
Hospitality — Jack Duvall
Public Address and Recording — Edwin W. Templin, John Stark, James Pettus, Harold Arthur, Frank Pontius

New ACME MATTE SHOT *Printer*

Photographing and printing composite and stationary matte shots

The Printer is readily converted to project an image of the master positive on a matte board. After painting the matte and threading duplicating negative raw stock in contact with the master, the printer is then used as a camera which selectively prints that portion of the master positive print that is desired. By substituting a painted scene at the matte board, and removing the master positive, a composite duplicating negative is made.

MOVEMENT: A stationary register pin Acme film movement, equipped with a removable back plate, readily converts the movement from a projector to a camera, or printer, type film movement. Because of the stationary register pin construction, positive film registration is attained regardless of the direction of travel.

SHUTTER: An automatic dissolve produces fades of six different lengths. Either a sine or a linear dissolving action may be obtained by pre-setting the dissolve dial.

CAPACITY: Two 1000-ft. rolls of processed stock and one 1000-ft. roll of raw stock. A film matte, the master positive and the raw stock will operate simultaneously in the machine.

POWER: Ten separate speeds are provided, with both continuous and stop motion action at all speeds.

BASE: Four feet of camera travel is accomplished with a hand wheel and the camera's position is indicated on a counter, enabling exact duplication of location.

Complete technical information will be furnished on request.

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Projection, 35mm and 16mm — Bundy Smith, G. J. Hessick, John Denney
Motion Pictures — Raymond Grant
Membership — John G. Frayne
Publicity — Harold Desfor, Martin Waldman
Ladies Program — Mrs. Philip G. Caldwell, Mrs. John G. Frayne
Luncheon — Carleton G. Hunt
Banquet — Sidney Solow

The Ladies' Program

The large group of ladies attending the Convention had a full program of sightseeing and entertainment ably organized by the committee headed by Mrs. John G. Frayne and Mrs. Philip G. Caldwell. The richness and success of the program were greatly enhanced by the kindness of the Altec-Lansing, Bell & Howell and Mole-Richardson companies, all of whom made generous financial contributions.—*D.C.*

Board Meeting

The Board of Governors' fourth meeting for the year 1954 was held at the Ambassador Hotel, Los Angeles, on October 16, on the eve of the Fall Convention. The budget, which had been of concern throughout the year, was reported on by Financial Vice-President Barton Kreuzer who said that expenses had been kept in line, and that economies necessitated by the 1954 mid-year budget reductions had been almost entirely achieved. A new budget for 1955, proposed by the headquarters staff, and recommended by the Executive Committee, was adopted and represents a conservative plan for next year.

Test Films. Growing importance of wide-screen pictures presents a challenge to the Society's test film program.

Membership. A number of new members had criticized the several weeks' time that admission to membership normally requires, being concerned no doubt about the delay in receiving the *Journal*. It was therefore decided that the *Journal* be sent on receipt of the application (and payment) and that only applicants' membership cards be held until the Admissions Committee has approved the applications.

Publication. The scale of operations for 1955 promises a reduced deficit and a bigger and better *Journal*, due to tight expense control and added income from advertising.

Conventions. It appeared certain that Convention operations for 1954 would be at or above budget. Since the Society has no formal policy on whether or not to hold educational or engineering exhibits at its national meetings, that decision is made for each time. Facilities at the Drake Hotel in Chicago are to be surveyed to determine whether an exhibit could be arranged for the spring 1955 Convention.

Editorial. Editorial Vice-President Norwood L. Simmons reported that Arthur C. Downes, for many years Chairman of the Board of Editors of the Society, was ill and that his work is temporarily being carried out by the Editor, with special help by members of the Board of Editors. In view of Mr. Downes' exceptional services to the Society through continued and effective control of the selection of editorial material for publication in the *Journal* it was resolved that he be presented with a special Commendation Award. This was later presented, in absentia, by President Barnett at the Get-Together Luncheon that opened the 76th Convention.

Engineering. Engineering Vice-President Axel G. Jensen presented a report showing that engineering activities of the Society were continuing at a high and efficient rate, as indicated in part by the number of standards regularly submitted to the ASA for approval.

Election and Awards. Secretary Edward S. Seeley announced the results of the balloting for the Society's Officers and Governors and for the annual Awards, including the Special CinemaScope Award. Details may be found in the November *Journal*, p. 198, and in the 76th Convention Report in the current *Journal*.

Since Barton Kreuzer had been elected to the office of Executive Vice-President midway through a two-year term as Financial Vice-President a one-year vacancy for the latter office was created which, under By-law III, Sec. 5, ". . . shall be filled by the Board of Governors until the Annual Election of the Society." Subsequent to the Board Meeting President-Elect John G. Frayne secured agreement from John W. Servies to accept appointment to fill the vacancy for the calendar year 1955. This action was endorsed by the Board.

Reports from the Sections were presented and adopted, and a proposal to establish a new subsection in Rochester, N.Y., was approved.

The next meeting of the Board will be on January 28, 1955, in New York.—*B.N.*

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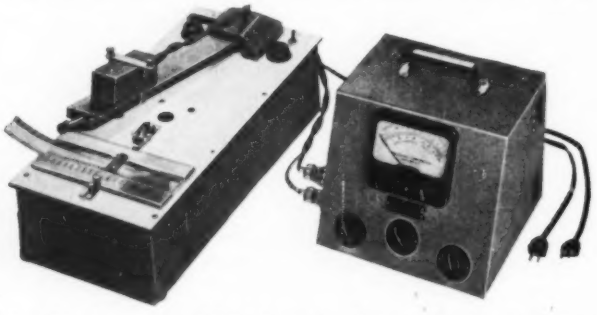

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Papers Presented at the Los Angeles Convention, October 18–22

MONDAY AFTERNOON—Color-Television

S. W. Athey, General Precision Laboratory Inc., Pleasantville, N.Y., "Colorimetric Aspects of Television Color Film Pickup."

George R. Sutherlen, U.S. Naval Ordnance Test Station, China Lake, Calif., "Multi-Channel Television Relay Station."

John W. Million, Jr., and Robert K. Hunsicker, Wickes Engineering and Construction Co., Camden, N.J., "Test Instruments for Color Television Broadcasting."

MONDAY EVENING—CBS Television City

G. Jones, Conrac Inc., Glendale, Calif., "Color Television Monitor."

G. R. Tingley, D. J. Pounds and J. H. Haines, Allen B. Du Mont Laboratories, Research Div., Passaic, N.J., "Operational Techniques for Color-Film Scanners."

Richard S. O'Brien, CBS Television, New York, "Color Television Facilities in CBS TV City."

TUESDAY MORNING—Educational and Military Television

James J. Rue, Telecommunications Dept., University of Southern California, Los Angeles, "The Present and Future of Educational Television."

Lt. Col. Edward L. Scheiber and Capt. Hugh C. Oppenheimer, U.S. Army Signal Corps, Washington, D.C., "Tactical Television."

Reid R. Davis, National Broadcasting Co., New York, "Color Television in Military Combat."

TUESDAY AFTERNOON—Television

Albert Abramson, CBS Television, Hollywood, Calif., "A Short History of Television Recording."

E. Hutto, Jr., Engineering Products Div., Radio Corp. of America, Camden, N.J., "Equipment for Evaluating Lenses of Television Systems."

O. Wittel and D. Haefele, Eastman Kodak Co., Rochester, N.Y., "Continuous Projector Problems."

Edwin C. Fritts, Camera Works, Eastman Kodak Co., Rochester, N.Y., "A 16mm Projector for Operation with a Television Film Chain on a Partial Storage Basis."

Lawrence C. Brunswick, Colorvision, Inc., Los Angeles, "New Separation Process for Color Motion-Picture Photography on Black-and-White Film for Color Television."

T. Gentry Veal, Chairman, "Television Committee Report."

TUESDAY EVENING—Color Television

A. C. Luther, Radio Corp. of America, Camden, N.J., "Color-Film Equipment."

L. L. Evans, Radio Corp. of America, Camden, N.J., "Color-Television Projection Equipment."

E. Dudley Goodale, National Broadcasting Co., New York, "Recording Color-Television Signals."

William B. Lodge and Howard A. Chinn, CBS Television, New York, "Color-Television Film Shooting Practices."

Sidney P. Solow and Edward H. Reichard, Consolidated Film Industries, Hollywood, "Some Laboratory Procedures in Preparing Television Prints in Black-and-White and Color From Eastman Color Negative."

WEDNESDAY MORNING—Magnetic Sound for Television Films

Edward Schmidt, Reeves Soundcraft, N.Y., "The 16mm Magnastriper."

Ralph E. Lovell, National Broadcasting Co., Hollywood, "A Suggested Procedure for Magnetic Striping of 35mm TV Films."

Ralph E. Lovell, NBC; Harlan L. Baumbach, General Film Labs.; Ellis W. D'Arcy, Consulting Engineer; Lorin D. Grignon, 20th Century-Fox Films; Ross H. Snyder, Ampex Corp.; "Panel Discussion of the Factors Pertinent to Obtaining Magnetic-Stripe Soundtracks on Television Films, both 16mm and 35mm."

WEDNESDAY AFTERNOON—Magnetic Recording

Jerome W. Stafford, Sound Dept., Metro-Goldwyn-Mayer Pictures, Culver City, Calif., "An Electronic Comparator for the Automatic Inspection of Magnetic Sound Prints."

M. Rettinger, Radio Corp. of America, Hollywood, "Magnetic Head Wear Investigation."

Ellis W. D'Arcy, Committee Chairman, "Report of Magnetic Recording Subcommittee."

Robert Schwartz, Sheldon I. Wilpon and Frank A. Comerci, Material Lab., Bureau of Ships, New York Naval Shipyard, Brooklyn, "Development of a Method for Measuring the Magnetic Strength Existing on 16mm Magnetic Soundtrack."

C. C. Davis, Westrex Corp., Hollywood, "A Moving Coil Feedback Disk Recorder."

Frank A. Comerci, Material Laboratory, Bureau of Ships, New York Naval Shipyard, Brooklyn, "Perceptibility of Flutter in Speech and Music."

THURSDAY MORNING—Motion-Picture Equipment

Frank G. Back, Zoomar, Inc., Glen Cove, L. I., N. Y. "A New Studio Zoomar for 35mm Motion-Picture Work."

Walter Wallin, Panavision Inc., Los Angeles, "Acceptable Definition in Anamorphosed Images."

John D. Hayes, Bausch & Lomb Optical Co., Rochester, N.Y., "CinemaScope Camera Lenses."

V. C. Chambers and W. R. Holm, E. I. du Pont de Nemours & Co., Inc., Parlin, N.J., "A Method for Splicing Motion-Picture Film."

THURSDAY AFTERNOON—(Concurrent Sessions)

High-Speed Photography

Carlos Elmer, Chairman, Panel discussion of the program presented at the 2nd International Symposium on High-Speed Photography held in Paris.

Film Projection

R. Clark Jones, Polaroid Corp., Cambridge, Mass., "A New Method of Describing and Measuring the Granularity of Photographic Materials."

R. M. Altman, A. E. Neumer and H. H. Schroeder, Bausch & Lomb Optical Co., Rochester, N.Y., "Consideration of Improvements in Condensing Systems for 35mm Projection."

Ralph H. Heacock, Radio Corp. of America, Camden, N. J., "CinemaScope in Drive-in Theaters."

Petro Vlahos, Motion Picture Research Council, Hollywood, "An Improved High-Brightness Screen for Drive-in Theaters."

J. E. Volkman, Radio Corp. of America, Camden, N.J., "Stereo Panoramic Sound."

THURSDAY EVENING—Wide-Screen Processes and Stereophonic Sound

W. Borberg, General Precision Laboratory Inc., Pleasantville, N.Y., "Brief Description and Demonstration — Air Blast on a Projector Aperture."

Loren L. Ryder, Paramount Pictures Corp., Hollywood, "VistaVision Exhibition."

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Henry E. Fracker, Charles F. West and Loren L. Ryder, Paramount Pictures Corp., Hollywood, "Framing of VistaVision Pictures."

John G. Frayne, Westrex Corp., Hollywood, "A Compatible Photographic Stereophonic Sound System."

FRIDAY MORNING—(Concurrent Sessions)

——High-Speed Photography

Webster Blake, Douglas Aircraft Co., Santa Monica, Calif., "Simple Electronic Timing Device for High-Speed Photography."

G. A. Economou, Sandia Corp., Albuquerque, N.M., "A Tracking Twin Telescope Mount."

Fred A. Metlen, Seattle, Wash., "High-Speed Motion Pictures and Sequence Photographs of the Same Event."

——General Motion-Picture Photography,

Glenn E. Matthews and Raife G. Tarkington, Eastman Kodak Co., Rochester, N.Y., "Early History of Amateur Motion-Picture Film."

C. R. Fordyce, J. M. Calhoun and E. E. Moyer, Manufacturing Experiments Div., Eastman Kodak Co., Rochester, N.Y., "A Light Meter for Printer Control."

Frank P. Herrnfeld, Frank Herrnfeld Engineering Corp., Culver City, Calif., "A System for Automatic Additive Printing and Scene Testing of Color Film."

FRIDAY AFTERNOON—(Concurrent Sessions)

——High-Speed Photography

Roderick M. McClung, U.S. N.O.T.S., China Lake, Calif., "Recording and Assessment of Telemetered Data."

R. Kuhagen and D. Stern, Gordon Enterprises, North Hollywood, Calif., "Modifications of Military Photographic Equipment."

R. C. Wheeler, Northrop Aircraft, Hawthorne, Calif., "Photographic Techniques as Applied to Optical Inspection of Transparent Solids."

——Color Film Sensitometry

O. E. Miller, Color Technology Div., Eastman Kodak Co., Rochester, N. Y., "Sensitometers for Color Films."

W. L. Brewer and S. A. Powers, Color Technology Div., Eastman Kodak Co., Rochester, N.Y., "Color Densitometers: Performance Characteristics."

M. C. Goddard and S. A. Powers, Color Technology Div., Eastman Kodak Co., Rochester, N.Y., "Color Densitometers: Control Methods."

John G. Frayne and J. H. Jacobs, Westrex Corp., Hollywood, "Densitometers for Control of Color Motion-Picture Film Processing."

FRIDAY EVENING—Color

Ralph M. Evans, Color Technology Div., Eastman Kodak Co., Rochester, N.Y. "Color and Brightness in Projected Color Pictures."

The expanding use of 16mm films for educational purposes is shown in some interesting statistics released at the National Audio-Visual Association's convention in August. Children today, they say, see six times as many films in school as did youngsters in 1940. In colleges, use of educational films and audio-visual presentations has increased ten times in the same 14-year period. Chicago, where the school system owns more than 1100 sound film projectors, reports an increase of 50% in the use of these materials in the past five years.

Indicative of the growth of the educational film production industry is the estimate from the Los Angeles city schools that more than 2300 films are submitted for previewing each year.

NAVA says that this growing use of modern audio-visual teaching tools costs the taxpayer very little. In Connecticut, the cost per student in an average-size school is reported to be $0.73 per semester. Indiana estimates the per pupil cost there at $1.10.

Employment Service

These notices are published for the service of the membership and the field. They are inserted for three months, at no charge to the member. The Society's address cannot be used for replies.

Positions Wanted

Electronic Engineer. 20 yrs experience in all phases of audio; responsible for prominent part in development of the Perspecta stereophonic system; comprehensive experience in technical education, classroom, laboratory and the preparation of textbooks and technical literature; advanced training in economics and industrial administration; many responsible posts held. British born, came to U.S. July 1953. Active member I.E.E., I.R.E., A.E.S., SMPTE. Seeks progressive position in West. Write: Norman H. Crowhurst, 150-46 18th Ave., Whitestone 57, N.Y.

Motion Picture Production. Desire position as cameraman. Seven years experience includes, as well as camera, some lab and editorial work. Full details given on request. Available after 15 April. Age 24 and single. Will locate anywhere. Write: Norman E. C. Naill, College Ave., New Windsor, Md.

16mm Motion-Picture Production. Would like position with aggressive, responsible firm with opportunities for advancement. Have been operating own film company majoring in TV film commercials but am now liquidating as present market holds little future. Has been mainly one-man operation: selling, writing, producing, billing and collecting. Have had successful business but area offers no future for advancement. Will send audition film. Will make permanent move only. Age 28. Write: M. R. Young, T-V Commercial Films, 1215 No. Copia St., El Paso, Texas.

Positions Available

Timers, color and/or black-and-white film required by motion-picture laboratory. Supervisory experience or ability desired. Send resume and small photograph to Du Art Film Labs, Inc., 245 West 55 St., New York 19.

Photographic Equipment Technologist, $5940 per year. Applicants must have bachelor's degree in technology, engineering or one of the physical sciences, plus 3 yr professional experience of a scientific or technical nature, including 2 yr of difficult and important work in the technology of photography; *or* 4 yr experience, demonstrating a mastery of the fundamental physical and mathematical sciences underlying professional technological work and a theoretical and practical understanding of the application of those sciences to photography which is comparable to that acquired by completion of a standard technological or scientific curriculum in an accredited college, may be substituted for the required bachelor's degree. Write: David A. Lana, Head, Industrial Relations Dept., Office of Naval Research, Special Devices Center, Port Washington, N.Y.

Membership Certificates. Attractive hand-engrossed certificates, suitable for framing for display in offices or homes, may be obtained by writing to Society headquarters, at 55 West 42d St., New York 36.

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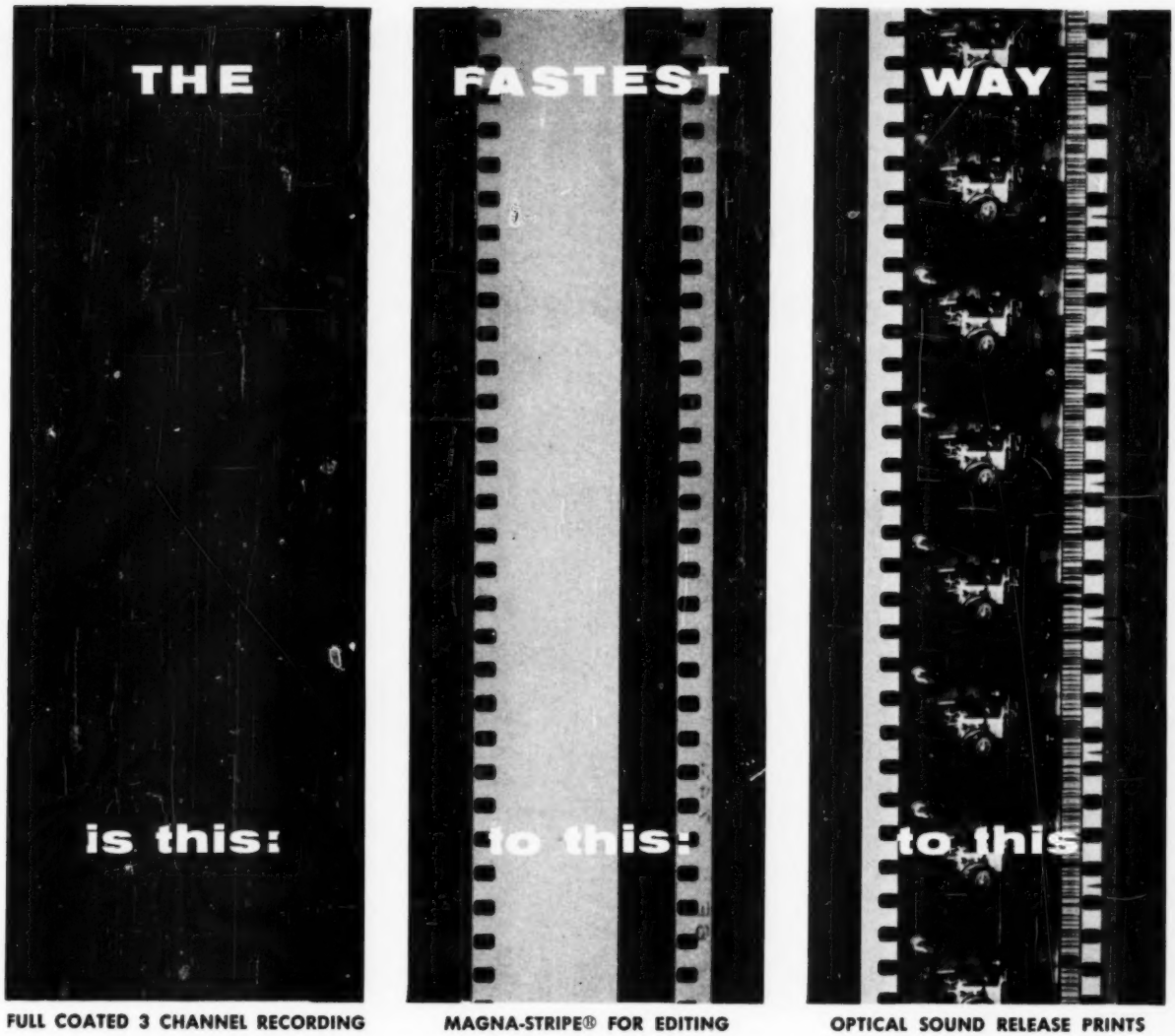

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Both the 35-mm and 17.5-mm Soundcraft full-coated stock come with or without footage marks. The 35-mm stock is also available coated between sprocket holes only, where a clear edge is desired. Full-coated 16-mm is available with either single or double perforations.

For full details on how Soundcraft Full Coated and "Oscar"-winning Magna-Striped Films can improve your original and edited sound tracks, speed your work, and open new business frontiers, write Dept. AB 12

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Journals Available and Wanted

These notices are published as a service to expedite disposal and acquisition of out-of-print Journals. Please write direct to the persons and addresses listed.

Available

Journals from July 1948 through September 1956, including covers, directories, indexes, etc. Excellent condition. $30.00 FOB. Write Hal Mesergle, 4812 Cooper Lane, Hyattsville, Md.

Dec., 1936; Jan., Feb., Apr., May, July, Sept., Nov. 1937; 1938 complete; 1939 complete; 1940 complete; Jan.-Aug. 1941. Write Richard S. Horton, Warner News Inc., 600 Madison Ave., New York, 22.

Collection of back issues available either singly or as a lot. Write P. H. Cole, 1258 So. Dunsmuir Ave., Los Angeles 19.

Wanted

Complete set of Transactions. Write John Flory, Eastman Kodak Co., 343 State St., Rochester 4, N. Y.

High-Speed Photography, Volumes 1, 2 and 3. Write Josh Gerber, Armour Research Foundation, Technology Center, Chicago 16.

Transactions Nos. 6 and 9. Write W. W. Hannan, 886 West 41 St., New York.

Signal Corps Pictorial Center would use a complete set of Journals, preferably as a donation. Write John F. Byron, Motion Picture Equipment Br., Signal Corps Pictorial Center, 45-13 48 St., Long Island City 4, N.Y.

Transactions Nos. 1, 5, 6, 7 and 9. Write Lloyd E. Varden, Reveres Center No., 535 West 57 St., New York 19.

Meetings

American Association for the Advancement of Science, Dec. 26-31, U. of California, Berkeley, Calif.

Radio-Frequency Measurements Conference, sponsored by IRE-AIEE-URSI-NBS, Jan. 17-19, Washington, D.C.

SMPTE Central Section, Jan. 17, Feb. 21, Mar. 21, May 16, June 15.

American Physical Society, Jan. 27-29, Hotels McAlpin and New Yorker, New York.

American Institute of Electrical Engineers, Winter General Meeting, Jan. 31-Feb. 4, Hotel Statler, New York.

Institute of Radio Engineers, National Convention, Mar. 21-24, Kingsbridge Armory, Bronx, N.Y.

Optical Society of America, Apr. 7-9, Hotel Statler, New York.

77th Semiannual Convention of the SMPTE, Apr. 28-May 2, Drake Hotel, Chicago.

The International Conference on Illumination to hold its next international conference in Zürich, Switzerland, June 25-27. Offers of papers should be addressed to the International Technical Paper Committee (A. A. Brainerd), 1015 Chestnut St., Philadelphia 7. Manuscripts must be in the hands of the Central Bureau between Oct. 1 and Dec. 31, 1956.

American Institute of Electrical Engineers, Summer General Meeting, June 27-July 1, New Ocean House, Swampscott, Mass.

Biological Photographic Association, Annual Meeting, Aug. 30-Sept. 2, Wisconsin Hotel, Milwaukee.

78th Semiannual Convention of the SMPTE, Oct. 8-12, Lake Placid Club, Essex County, N.Y.

American Institute of Electrical Engineers, Fall General Meeting, Oct. 5-7, Morrison Hotel, Chicago.

Photographic Society of America, Annual Convention, Oct. 7-13, Sheraton-Plaza Hotel, Boston, Mass.

American Standards Association, 37th Annual Meeting and Sixth Annual Conference on Standards, Oct. 24-25, Washington, D.C.

79th Semiannual Convention of the SMPTE, Apr. 29-May 4, 1956, Hotel Statler, New York.

80th Semiannual Convention of the SMPTE, Oct. 7-12, 1956, Ambassador Hotel, Los Angeles.

81st Semiannual Convention of the SMPTE, April 28-May 3, 1957, Shoreham Hotel, Washington, D.C.

82d Semiannual Convention of the SMPTE, Oct. 6-11, 1957, Hotel Statler, New York.

SMPTE Officers and Committees. The rosters of the Officers of the Society, its Sections Subsections and Chapters, and of the Committee Chairmen and Members were published in the April Journal.

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